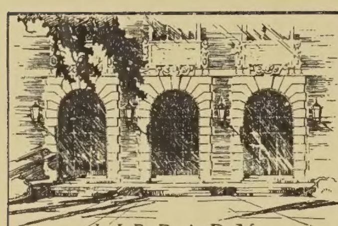

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AUTHOR OF "SATURN AND ITS SYSTEM," "OTHER WORLDS THAN OURS," "SUN-VIEWS OF THE EARTH," ETC. ETC.

AND PHOTOLITHOGRAPHED BY

A. BROTHERS, F.R.A.S.

AUTHOR OF "A CATALOGUE OF THE KNOWN AND SUSPECTED BINARY STARS."

WITH A LETTER-PRESS INTRODUCTION.

Ἐν δὲ τὰ τείρεα πάντα, τά τ' οὐρανὸς ἐστεφάνωται.
HOMER.

Ταῦτά κε θηήσαιο, παρερχομένων ἐνιαυτῶν,
Ἑξείης παλίνωρα· τὰ γὰρ καὶ πάντα μαλ' αὔτως
Οὐρανῷ εὖ ἐνάρηρεν ἀγάλματα νυκτὸς ἰούσης.
ARATUS.

LONDON:
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LATE PRESIDENT OF THE ROYAL ASTRONOMICAL SOCIETY,

I NOW SORROWFULLY DEDICATE

To His Memory.

R. A. PROCTOR.

INTRODUCTION.

IT may appear to savour of undue boldness to assert that during all the long years which have elapsed since the stars were first charted, the true principle on which a general Star-Atlas should be constructed has remained unrecognized. And, perhaps, it may seem even more venturesome to say that there is only one plan according to which such an Atlas *can* be constructed so as to satisfy even the chief requisites which Star-Charts are intended to meet. Yet I think I shall have no difficulty in establishing not only these two assertions, but *this* also, that the present Atlas is the first ever constructed from which it is possible to gather any clear ideas respecting the general laws according to which the stars visible to the naked eye are distributed over the heavens.

In the first place, let me lay down the general principles on which the value of a system of star-charting may be said to depend.

It is clear that, *cæteris paribus*, that plan is best which represents the celestial sphere in the smallest number of maps. Further, the maps should be convenient in size, but yet on a sufficiently large scale; and of two plans, otherwise equal, that one will be best which, on a given scale, and with a given number of maps, makes the maps cover the least possible area. It is also obvious that the distortion and scale-variation of a map should be as small as possible.

And now to consider details:—

In the first place, it is clear that all the maps of an Atlas should be of equal size. If we are to have ten maps, suppose, and we divide the sphere into ten unequal portions, one of these at least will be greater than a tenth part of the sphere. The greater the part of the sphere included within a map, the greater (inevitably) will be the maximum distortion. Hence our purpose will be best fulfilled when all the maps are equal. And the same result holds whatever may be the number of maps into which we propose to divide the celestial sphere.

Secondly, it will be best that the distortion should come in uniformly round the central point of the map. For obviously, though in certain parts of the map we might gain by using a non-central projection, we should lose as much in others; and so we should lose on the whole, since the effective distortion of a map is the maximum distortion found within the map. What is required then is a central projection. Now in such a projection the distortion and scale-variation increase with distance from the centre; and thus the value of a set of maps will be increased by any plan which reduces the maximum extension of the map-distances from the centres. This is a most important principle.

But thirdly, it will now be clear that all the maps of a series should be alike in *shape* as well as in size. Suppose, for instance, that there are to be ten maps, each covering exactly one-tenth part of the sphere. Then we might reduce the distortion in one map to a minimum, by making it circular—that is, by including within it a *segment* of the sphere; or we might do this for two maps of the set; but some of the others would suffer in consequence; we should have to give to one or two, at least, a shape unnecessarily irregular, and so having parts unnecessarily far from the central point of projection. Thus we should lose on the whole,

because the value of a scheme of projection is not to be judged by the distortion in this or that map, but by the maximum distortion found anywhere throughout the series. Our best course, therefore, will be to distribute equally among the maps the range of distance from the centre; that is, to make all the maps alike in shape.

These three considerations enable us to reject all schemes of division except one.

The sphere can only be divided into equal parts in five ways, corresponding to the five regular solid figures. Imagine a sphere enclosed within a regular triangular pyramid; that is, a pyramid having an equilateral triangle for base, and three sides each equilaterally triangular: then, if a line be supposed always to pass through the centre of the sphere and to be carried along the six bounding edges of the enclosing pyramid, its intersection with the sphere will mark out the boundaries of four equal and similar spherical triangles into which the sphere will be divided. Let the sphere be enclosed in a cube, and a movable line (always passing through the sphere's centre) be carried along the twelve edges of the cube; then the sphere will be divided into six equal and similar spherical quadrilaterals. So if the sphere be enclosed in a regular octahedron (*i.e.* a regular double pyramid) and a like process employed, the sphere will be divided into eight equal and similar spherical triangles. Fourthly, if the sphere be enclosed within a regular dodecahedron, it can be divided in like manner into twelve equal and similar spherical pentagons. And lastly, if the sphere be enclosed within a regular icosahedron, it can be divided by a movable line as before into twenty equal and similar spherical triangles.*

Now it is very easy to select between these five modes of division. The great point to be noticed is the distance at which the angles of the divisions fall from the centre of each division. The greater this angle the greater the distortion. The effective distortion will indeed be as great as though each division were extended so as to include the spherical segment whose bounding circle runs through the angles of the division. What these angular distances are, is shown in the following table :—

	Distance of angles from centre of map would be		
For the tetrahedron or triangular pyramid	70°	31′	43·6″
hexahedron or cube	54	44	8·2
octahedron or double pyramid	54	44	8·2
dodecahedron	37	22	38·5
icosahedron	37	22	38·5

We thus have only three angular distances to choose between, and can at once eliminate the octahedron and icosahedron, which present the same measure of distortion as the cube and dodecahedron respectively, while dividing the sphere into more parts. Nor is it difficult to select between the remaining three. To present a map having angles removed 70° 31′ 43·6′ from the centre of projection, is as difficult as to present a map extending round the centre on all sides to that distance. Such a map would cover exactly a third part of the sphere. Obviously no plane chart can include such a large proportion of a globe as this without great distortion. Again, to present a map having angles removed 54° 44′ 8·2″ from the centre, would be equivalent to presenting a circular map having an arc-radius of this magnitude. Such a map would cover considerably more than a fifth part of the sphere; † and though this is

* There is another mode of conceiving the division of the sphere into equal and similar figures, which is worth noticing. Suppose the centre of a sphere to be a luminous point, and that a regular solid lies within the sphere, all its angles lying on the surface of the sphere. Then if the edges of this solid are opaque, the solid itself being transparent, their shadows on the sphere's surface will be the bounding lines of equal and similar spherical divisions.

† The actual extent of such a maps would, of course, bear to the area of the sphere the ratio which the versed sine of 54° 44′ 8·2″ bears to 2; this is easily found to be about the ratio of 21,137 to 100,000. In the case of the dodecahedron the corresponding proportion of the sphere is represented by the ratio 10,267 to 100,000, or less than half the former. But a more truthful and even more effective way of comparing the two modes of division is the following :—

Of all central projections the equidistant is the one which least markedly displays the defects of maps covering

better that the former case, yet it is still wholly impossible to present so large a proportion of the sphere without great distortion. Now when we consider the case of a map having angles removed 37° 22′ 38·5″ from the centre, we find a great diminution in the extent of surface we have (in effect) to deal with. For a circular map having an arc-radius of this magnitude covers very little more than a tenth part of the sphere (in reality ·10267 of the sphere).

Even this, however, might at first sight seem more than we can present without considerable distortion; and it is in considering the method of resolving the difficulty that all other modes of projection but the one here made use of are eliminated. Only three central projections are applicable to such a problem,—the *gnomonic*, the *stereographic*, and the *equidistant*.

The gnomonic method is used in the index-maps, a glance at which will show that, however useful the projection may be for special purposes, it is wholly unequal to answer our chief purpose, which is to get rid of all marked distortion. It is clear that the spaces between meridians and parallels near the angles of the index-maps differ markedly in shape from the corresponding spaces on the sphere. That test is decisive.

The stereographic projection seems more promising. It is a peculiarity or this mode of projection that it exhibits no distortion whatever so far as small figures are concerned, and also that all angles remain unchanged. Now, if this absence of distortion extended to large figures also, the stereographic projection would have so great a superiority over all others in this respect that we could hardly conceive that superiority in other respects could bring other plans on a level with it. But of course this cannot be the case. It is obvious that a mode of projection which exhibited small and large parts of the sphere undistorted, would exhibit all parts on their true scale, and this no plane chart can possibly do.

It remains then to consider whether the stereographic or equidistant projection gives the most favourable result, when scale-variation, area-variation, distortion of small areas, and distortion of large areas, are all considered together, and due weight given to the advantages of either projection in each several respect.

In the stereographic projection applied to a map having an arc-radius of 37° 22′ 38·5″, the maximum scale-variation is from 1 to 1·116, while in the equidistant projection the scale-variation is but from 1 to 1·075; so that while the scale increases by more than one-ninth in the stereographic projection, it increases by less than one-thirteenth in the equidistant. The area-variation is from 1 to 1·245 in the stereographic, and from 1 to 1·075 in the equidistant; so that while the area-scale increases by nearly one-fourth in the stereographic projection, it increases by less than one-thirteenth in the equidistant. Now as regards distortion, it will be obvious that the advantage derived from the absence of distortion of small areas in the stereographic projection is fully balanced by their greater increase of size as compared with what appears in the equidistant projection; for in judging of a small group of stars the eye will be quite as much deceived by a modification of its size as compared with other groups, as it would be by a slight modification of its figure. But the distortion of small areas in the equidistant projection, altogether insignificant and to most eyes inappreciable in the present instance (as any one will see by comparing the spaces between meridians and parallels in the centre of any of the maps in this Atlas, with the corresponding spaces near the edge of the map), is far more than counterbalanced by the superiority this mode of projection has over the stereographic as respects the small distortion of large areas. It need hardly be said that if one part of a con-

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a large part of the sphere. Therefore this method will give the most favourable results for the cubical division of the sphere. Now the distortion and scale-variation on this projection are measured by the ratio which the excess of arc over sine of angular range of a map from the centre bears to the sine of this angular range. Thus we have the following proportion :—

$$\left\{\begin{matrix}\text{distortion in cubical}\\ \text{division of sphere}\end{matrix}\right\} : \left\{\begin{matrix}\text{distortion in dode-}\\ \text{cahedral division}\end{matrix}\right\} :: \frac{\text{arc } 54° 44' - \sin 54° 44'}{\sin 54° 44'} : \frac{\text{arc } 37° 23' - \sin 37° 23'}{\sin 37° 23'}$$

$$:: \frac{13886}{81647} : \frac{4532}{60714} \text{ or about as } 2\tfrac{1}{4} \text{ to } 1.$$

And in this ratio, at the very least, does the dodecahedral mode surpass the cubical mode of division.

stellation is affected as respects area by an increase of nearly one-fourth, the whole aspect of the constellation cannot but be appreciably altered; which is not the case where no part of a constellation is affected by an increase of so much as one-thirteenth. In addition to these conclusive considerations, the equidistant projection will give smaller maps than the stereographic, on a given scale.

Thus the equidistant projection is to be preferred to the stereographic in this case. And further, no one can doubt that while the stereographic projection introduces a change of area sufficing to render that projection unsuitable for a Star-Atlas, the equidistant projection, which gives no greater distortion than that resulting from a longitudinal increase of parts of the maps by less than one-thirteenth of their extension on the sphere, does really meet the requirements of the case.

In other words, *it has been proved that the plan of projection used for the first time in this work is the only one which is fit to be applied to the construction of a celestial Atlas.**

Already, too, it is manifest that no Atlas hitherto constructed could give clear ideas respecting the laws according to which the lucid stars are distributed over the heavens. For, in order to discover such laws, a uniform mode of dividing the sphere is absolutely essential; and the only uniform mode of division actually adopted until now, is that employed in the maps published by the Society for the Diffusion of Useful Knowledge. Now, in these maps a mode of projection is made use of which actually gives an increase of scale from 1 to 5·19; so that in certain regions of the heavens stars might be spread in reality *five times as richly* as elsewhere, and yet in these maps those very regions might be presented as relatively *somewhat barer* than the rest.†

The only plan really fit for constructing a Star-Atlas having been discovered, it remained to consider how that plan might most effectually be applied.

Remembering that the heavens are not marked with meridians and parallels, or with circles of longitude and latitude, but with stars, it would be for many reasons convenient if maps could be arranged with reference to the actual configuration of star-groups rather than to the imaginary lines and circles used by astronomers. Two men of science, both of great eminence in their respective walks, have indeed suggested to me the adoption of some such plan. But when I considered how closely the accepted methods of marking the celestial sphere have become associated with all the processes employed in astronomical observation, I felt that these methods must be employed in any celestial Atlas meant for general use; and it became further clear to me that if the circles and parallels of declination are to be introduced into any Atlas, they must be introduced on a systematic and clearly intelligible plan. The connection between the several maps, and their relation to the poles of the heavens and to the celestial equator, *must* be made clearly recognizable.

This admitted, it was obvious that one of the twelve pentagonal maps must have the north pole for its centre, the opposite one the south pole. Accordingly, the first and twelfth maps of the present series are *polar* ones. The remaining ten thus become *equatorial* maps, five being northern, the other five southern.

Next, the meridian corresponding to 0^h of right ascension must fall either on the middle or along the side of a pentagonal map (two boundaries of each pentagonal map except the polar ones being necessarily meridians). It was a matter of no moment, so far as symmetry was concerned, whether this meridian passed through the middle of a northern equatorial

* The considerations leading to the selection of the present mode of dividing the sphere and projecting each map are so obvious and simple, that I could not persuade myself for a long time that they had not occurred to astronomers before. Even now, though I have searched in vain for traces of maps constructed on my plan, I should hardly be surprised if I found that I have unwittingly adopted a plan already advocated by others.

† This is no imaginary case. A part of Cygnus singularly rich in stars, happening to fall near an angle of the cube on which in the Society's maps the stars are supposed to be projected, appears considerably less rich than regions falling near the centre of some of the maps, where yet there are not in reality half as many stars, taking space for space on the heavens.

map and along an edge of a southern one, or *vice versâ*.* But as one arrangement might suit the actual configuration of the star-groups better, I inquired carefully which was to be preferred. I found that the constellations Orion and Ursa Major would be crossed by the boundary-lines of maps whichever plan was adopted, but that they *might* be preserved unbroken by an arrangement presently to be considered, if the meridian marking 0^h R. A. crossed the middle of a northern equatorial map, whereas Orion at any rate *must* be divided if this meridian traversed the side of a northern map. This settled the question; but it remains to be added that the resulting plan happens very fortunately to carry the edges of the maps most conveniently clear of all the principal star-groups, at least when the subsidiary contrivance now to be described is adopted.

The index-plates exhibit the real boundaries of the twelve pentagonal maps (except that along the equator the maps are extended beyond their true pentagon, whose outline is indicated by broken lines). It will be clear that, if these five pentagons were laid down on separate sheets, there would be a difficulty in carrying on the investigation of a star-group, when there was occasion to pass from one map to a neighbouring map. This is a difficulty which all who have used Star-Atlases must often have felt. Now in the index-plates the difficulty is in great part removed, because (i.) the five equatorial maps are brought into actual juxtaposition with their respective polar maps; (ii.) other edges (ten pairs) are brought near enough for comparison; and (iii.) overlapping pieces are appended to the remaining ten edges. But, besides that on the scale necessary for such an Atlas as the present, no such plan was available, the mode of projection actually adopted—the *equidistant*—does not give straight edges to the pentagonal maps. The idea, therefore, suggested itself to me, as tending to an obvious improvement of the Atlas, that, instead of letting each map include only a spherical pentagon, it should include the whole of that part of the sphere which lies within the circle circumscribing the pentagon. Thus each map overlaps the five neighbouring maps, and a star-group which has been followed in any one map to the edge can be taken up again, *not at the edge of another*, but well within its limits. Only at *twenty points*, instead of along *thirty arcs each nearly twenty-one degrees in length*, could any star-group be inconveniently broken; and it happens that no angle of any of the pentagonal maps falls where such breaking-off could be mischievous. Further, even near these angles three maps overlap, so that were there any star actually upon an angle, it would be brought into association with three differing areas lying all round it, and overlapping each other. It will be seen that the plan of overlapping has saved several important star-groups from being divided. Here and there the boundary-line has been broken to save other groups from division; and it will be found, on a careful study of the whole series of maps, that all the chief constellations, or rather all the recognized star-groups, are fully presented in one or another map. Orion is given in full (as regards the stars which form its characteristic features) in two maps. The seven bright stars of Ursa Major are given together in one map, and appear divided in two others; so that the association between this well-known group and three great stellar regions (three-tenths of the whole heavens) can be very clearly recognized.

The use of the index-plates in still further indicating the association between the different maps of the series will be also at once obvious.

The question of scale had next to be considered. It was necessary, on the one hand, that the scale should be sufficiently large to admit all the stars in the British Association Catalogue down to the sixth magnitude, inclusive, without crowding; while, on the other, it was desirable that the maps should be of a convenient size. It seemed to me that the scale of an 18-inch globe would meet both these requirements. If the stars which belong to the orders to be included were spread with tolerable uniformity over the heavens, the

* The study of the two index-plates, as compared one with the other, will exhibit the nature of the problems actually involved.

scale of a 15-inch globe would be sufficient; but as a matter of fact stars are so thickly congregated in certain regions that a larger scale is required. The scale of the index-maps being that of a 6-inch globe, while only 1,500 stars from the British Association Catalogue fall within those maps, it is clear that a scale giving four times as great an area per star would equally well suit the requirements of maps to include 6,000 stars. Thus the scale of a 12-inch globe would have been sufficient had the index-plates been on an adequate scale for general and observational purposes. But this seemed to me not to be the case. The scale of an 18-inch globe gives more than twice as much space per star as is given by the index-maps. The actual scale of the maps is, however, somewhat larger. The originals having been drawn by me on the exact scale of a 30-inch globe, it seemed to Mr. Brothers that our best plan would be to reduce by about one-third, as that would give maps conveniently proportioned to the size of the paper we proposed to use. Thus the scale of the present maps is, as nearly as possible, that of a 20-inch globe, or more than ten times the superficial scale of the index-plates.

Next as to the mode of construction.

In the polar maps, of course, the equidistant projection simply gives equidistant concentric circles for the declination-parallels, and a series of lines radiating symmetrically from the centre for the meridians. But in the equatorial maps, neither meridians nor parallels fall into the form of any curves ordinarily constructed. It seemed to me so important that these maps should be actually on the equidistant projection, and not merely approximations, that I determined to calculate the proper place (on any chart) of the intersections of meridians and parallels to every fifth degree,* and to take these curves through the points thus laid down, not in any case using any of the appliances for tracing ordinary curves, even when the actual curves closely approximated to circular or elliptical arcs. It seemed preferable that here and there some irregularity of appearance should perhaps manifest itself, rather than that the scheme of projection should be appreciably interfered with.

It will be seen, by the following description of the method employed, that no point of any one of the projections can be appreciably out of place.

Having described the half-circumference of an equatorial map (its radius the same, of course, as the radius of either polar map), I carefully divided it into 180 equal parts, adopting several tests to secure accuracy. Then for each point of intersection of meridians and parallels (to every fifth degree) I took first the calculated bearing from a central meridian line (straight, of course) by drawing a straight line from the centre to the proper part of the divided circumference. Then I measured off along this line the calculated arc-distance (using throughout a strip of stout paper, carefully marked with equidistant divisions along one edge). In this way I obtained all the points of intersection along meridian lines 5°, 10°, 15°, and so on, from the central one, over one half of a map. Through the points thus determined, I drew the corresponding meridians and parallels in pencil, adopting fit measures † to secure

* The calculation of the positions of the points of intersection of meridians and parallels was a simple operation, though taking some time. I had the polar distance of the central point of any equatorial map, namely 63° 26′ 5·8″, and a straight line through this point was taken to represent a meridian. Now to determine the place of a point differing a degrees in right ascension from the central point of the map, and having a polar distance ν, all that was wanted was the *bearing* (θ suppose) of this point from the central meridian (measured from the polar side suppose), and its arc-distance (x suppose) from the same centre as measured on the globe. From the fundamental properties of the equidistant projection these elements are the same in the planisphere as on the globe. Putting 63° 26′ 5·8″ = N for convenience, the formulæ for determining θ and x are as follows:—

$$\cos x = \cos \nu \frac{\cos (\mathrm{N} - \phi)}{\cos \phi}$$

$$\text{and } \tan \theta = \frac{\tan a \sin \phi}{\sin (\mathrm{N} - \phi)}$$

where ϕ is a subsidiary angle determined by the relation $\tan \phi = \tan \nu \cos a$.

† These measures are as follows for parts of a map where (as in this case) distortion is small. Suppose L, M, N to be three points through which a curved line has to be drawn, the distance between L and M very nearly equal to the distance between M and N, also LM and MN almost equally inclined to LN. Then through M one must draw a

everywhere the proper curvature. Then I divided the sides of each space enclosed between successive meridians and parallels into five equal parts (using a proportional compass), and by drawing through these points the intermediate meridians and parallels (with precautions for curvature, as before), I obtained a half-map exhibiting the meridians and parallels accurately laid down to every degree.

This done I used the half-map to prick down the points of intersection of successive meridians and parallels one degree apart, for all the ten equatorial maps—using the half-map directly for the right-hand half, and invertedly for the left-hand half. Thus I secured perfect uniformity among all the ten maps. I also had in this way a complete set of division-marks to guide me, so that in marking in a star from its catalogued place, I had not to set off its proportional distance in R. A. and N. P. D. from the bounding sides of the space within which it falls in the map. By simplifying the process of marking in each star, this tended to render the work much more accurate; for nothing tends so much to the introduction of errors as the continual repetition of a wearisome process. For a similar reason I found it well to pencil down the number of every degree of N.P.D. along successive hour-meridians, experience showing me that the trouble would be well repaid by the increased accuracy of the work, and the consequent avoidance of the necessity for frequent erasures. Yet another point tending to render the process of mapping surer and easier was the use of heavier lines for the hour-meridians and for every fifteenth parallel of declination.

In the polar maps I also completed the series of meridians and parallels to every degree, in pencil.

The process applied to each map was then as follows:—

First the longitude and latitude lines were marked in to every fifteenth degree, the positions of their intersections in R. A. and N. P. D. being determined from a careful construction applied to the orthographic projection of a hemisphere. Along the latitude-parallels the precession-arrows were pencilled, the length of each indicating the precession for 100 years. I now took the British Association Catalogue, and marked in each star in order, omitting all below the sixth magnitude, correcting for thirty years' precession by reference to the precession-arrows.* As each star was marked in I referred to the large maps of the S.D.U.K., compared its uncorrected place with the place shown in those maps (which being for 1840 are readily comparable with the B.A.C. places for 1850). In this way I avoided many errors into which I should otherwise have fallen, and detected also many errors in the S.D.U.K. maps,—whose accuracy is nevertheless wonderful, when due account is taken of the great number of stars they contain. I should have asserted that by this plan every star common to the S.D.U.K. maps and mine was certainly placed in its true place in my maps; but that on carefully comparing the completed map *again* with the S.D.U.K. maps, I never failed to find an error or two. I therefore conclude that no process, however systematic, will prevent some errors appearing in an Atlas which includes thousands of objects; and I feel convinced that neither the comparison star by star as the work proceeded, nor the general revision when all the stars from the B.A. catalogue were marked in, nor the final revision when the proof was submitted to me by Mr. Brothers, have secured for the maps a perfect immunity from error. No one who has not carried out a long process of star-mapping (or cataloguing) can be

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parallel to LN, extending one-fourth of the way towards L and one-fourth of the way towards N. If through L a line be drawn similarly related to KM (K being the next point beyond L), and through N a line similarly related to NO (O being the point next beyond N), and so on, and the broken line thus formed be completed by straight lines joining one with another, a polygonal line will be formed which will differ from the true curved line only one-fourth as much as a polygonal line formed by simply joining LM, MN, and so on. In the case under consideration, a curved line traced along the polygonal line drawn as described, in such a way as to touch every separate straight portion, will differ only in an altogether inappreciable manner from the true curved line.

* In practice, I kept three compasses open to the required precession-correction for uppermost, lowest, and a central latitude parallel; and for each star used the nearest precession, with an eye estimate of the minute amount by which the true precession was greater or less.

aware how every precaution one may contrive turns out ineffectual to prevent errors (and sometimes quite large errors) from making their appearance. I only assert, therefore, that I believe no atlas was ever constructed in which more pains were taken than in the present to avoid errors, without pretending that some may not have here and there escaped my scrutiny. I shall accept thankfully any corrections to which my attention may be called.

After the stars from the B.A. Catalogue had been marked in, I entered in order :—

First, all the nebulæ in Sir J. Herschel's Catalogue down to the order marked Very Bright, and all Messier's nebulæ, whether so marked or not.

Secondly, all the binaries and suspected binaries in Mr. Brothers' Catalogue.

Thirdly, all the objects in Admiral Smyth's Bedford Catalogue.

Fourthly, all the red stars in Dr. Schjellerup's Catalogue of 293 such stars, using Mr. Lynn's reduced places for the year 1870, as presented in Mr. Chambers's Astronomy.

Fifthly, all the variables in a complete list of all stars actually recognized as variable (136 in all), kindly prepared for me by Mr. Baxendell.

In marking in these objects I used the precession-arrows as in marking in the B.A.C. stars, with due reference to the date corresponding to each list. I also compared the place of each object with that given in the S.D.U.K. maps whenever an object belonged to the classes included in that series.

In the case of southern maps I next marked as double, triple, &c., all the stars already marked in, which are described as of such a nature in Sir J. Herschel's South Cape Observations, adding a few objects from that work; not so many as I otherwise should, because the southern maps are more crowded with stars than the northern, and would not readily bear such additions. I also marked as double, &c., all objects so noted in the S.D.U.K. maps which did not happen to have been included in any of the above-mentioned lists.

Next I marked in the constellation-outlines, arranging the stars according to the simple plan adopted in the Catalogue of the British Association. I then put in the names of the several constellations, choosing spaces as nearly vacant as possible. The addition of the numbers of right ascension and declination round the maps, of north polar distance down the central meridian, and of longitudes and latitudes upon the corresponding curves, with the indication of the numbers of the five overlapping maps, &c., completed my share of the work.

The originals were drawn, as I have said, on the scale of a 30-inch globe. Thus errors merely due to the difficulty of marking in a star on the exact point intended, are all much smaller than they would have been had the maps been originally drawn on the scale now presented. Nay, even if I had been able to mark in every star exactly in its true place on the smaller scale, and the most careful lithographic artist had attempted to make an exact copy, the errors resulting in this process must have been considerably greater than those accruing by the process actually adopted. Considering that no professional lithographer would undertake to produce a perfectly exact transcript of such a design, and that that design itself must have included greater proportional errors than those actually resulting in these reduced maps from the cause considered, I trust the inferiority of my work as regards the writing and such matters will be thought to be more than counterbalanced by the increase of accuracy resulting from the method actually employed. Let all who have had to revise their own work, as reproduced by the most conscientious artist, and who have noted the errors, omissions, and wrong interpretations which appear in the proofs submitted to them, consider the advantages of the plan actually adopted in these maps. I had but to glance over one of Mr. Brothers' skilful reductions of my maps, assuring myself that there was no accidental obliteration, blot, or the like, and at once I knew that *there* was my own work, accurately reproduced, and all the errors due to the unavoidable misplacement of objects considerably reduced.

As for the quality of the writing, lineation, &c., I have only to remark that the work was the best I could do,* and that no one recognizes more clearly than I do how it differs

* It must be remembered that, owing to the great size of the originals, the work of mapping was very wearying.

from the work of the practised "writers" employed by lithographers; but I believe it is at least perfectly clear and legible, while I have the comfort of knowing that no undetected errors of a professional assistant mar the accuracy at which I have at least aimed.

I have been most agreeably surprised by the manner in which, in Mr. Brothers' skilful hands, photolithography has been made available for reducing maps constructed on so large a scale.

And here I feel it very necessary to make a few remarks on the nature of Mr. Brothers' connection with the present work. In the first place, this Atlas would probably not have made its appearance for several years, if at all, but for the fortunate accident that in May 1869 I submitted my manuscript drawing of Map 8 to his inspection. It will be seen from a note on pp. 31 and 32 of my Handbook of the Stars, and from further remarks at p. x. of the preface of that work, that the plan of the present work has been in my thoughts, as regards all its essential points, during nearly four years, or since midsummer 1866; but owing to causes which need not here be entered into, I was unable to carry out my views; while two or three publishers, to whom I submitted the plan, feared that too many Star-Atlases already existed for this one to have any prospect of being commercially successful. In 1868, having a seat (which a pressure of engagements has since compelled me with much regret to resign) at the Council-board of the Royal Astronomical Society, I took the opportunity, at the advice of the late Admiral Manners and others, to submit the scheme to the consideration of my colleagues. I received many useful hints during the progress of the discussion which ensued, and most of these have since been attended to in the prosecution of my scheme; but it was their general opinion that if this project were submitted to them in their official capacity, they would be unable to advise the Society to devote any sum to the completion of the work, because such a course would afford a precedent which might be found inconvenient. A year afterwards, in the course of a conversation on astronomical matters with Mr. Brothers, it occurred to me to show him the same specimen-map which I had exhibited to my fellow-councillors of the Royal Astronomical Society. He at once interested himself in the scheme, and, a few days after, laid before me his views as to the best way of carrying it out. Besides this, however, and besides a number of useful suggestions on points of detail, he removed that difficulty, which had all along been my great perplexity in the matter, and kindly undertook to assist me in bringing the scheme before the public. Nothing I am sure but the great interest Mr. Brothers takes in the progress of science could have induced him to devote so large a share of his time and attention, as he has actually given, to the details of this work; and I wish it to be clearly understood, that his association with it has not been a business one (though all business details have been most skilfully managed by him), but scientific and friendly, and of such a nature as to put me under a great obligation to him.

I have used throughout these maps Colonel Strange's figures of the Arabic numerals, keeping a photograph of these figures, with which he was kind enough to supply me, always before me, and copying the very distinct and simple shapes as closely as possible.

A few words of comment are required respecting the nomenclature of the stars. All stars having Greek letters are so marked, nor have I thought it advisable to give to such stars, in addition, the number assigned them by Flamsteed, as is done in some atlases. The use of both letter and number, in such instances, not only encumbers an atlas needlessly, but serves more often to cause mistakes than to assist the student. To all stars not having

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The map had to be placed horizontally because of the large catalogues I had to refer to, and also because a star near the top of a map might be followed by a star near the bottom, &c., so that no slope could be adopted which would have been convenient for marking in successive stars. Thus all stars falling near the upper part of a map necessitated an attitude by no means favourable for good writing. Then, owing to the size of the maps, a stout kind of paper had to be used, in which steel pens and compasses worked (at least in my unpractised hands) most unpleasingly. The adoption of Col. Strange's suggested mode of indicating the Arabic numerals, though obviously advantageous on the score of distinctness, involved some difficulty in execution, as the figures are not such as one is in the habit of making, and their uniform thickness makes them much less easy to draw than the ordinary ones.

Greek letters, but numbered by Flamsteed, I have given his number. To all stars marked with Italic letters, or small Roman capitals, in the four subdivisions of Argo, their proper letters have been assigned in this Atlas. So far as the 5,932 stars belonging to the British Association Catalogue are concerned, these are all the modes of nomenclature systematically adopted. Thus a large number of these stars (especially in the southern maps) remain wholly unnamed. It has seemed to me at least as proper that these stars should be recognizable by their right ascensions and declinations, as compared with those given in the British Association Catalogue, as that they should be indicated by numbers of three or four figures, referring to the catalogues of Lacaille, Brisbane, and others. But, besides, the main purpose of this Atlas—to wit, the truthful representation of the heavens—would have been defeated if such numbers as these had been suffered to encumber the maps.

As the Arabic names of the stars are still recognized, it seemed advisable that, though all but a few have been banished from my maps, this work should provide the means of ascertaining the Arabic names of a far larger number.

An alphabetical list of the constellations is given, with the number of the map in which the constellation is to be found; and in all cases where they occur on two or more maps, the references outside the borders will be found sufficient.

All objects—double stars, nebulæ, variable stars, &c.—have been numbered or lettered in these maps, where they have received any title. The most convenient appellation has been used where such a star has more than one number or letter. A red, double, or variable star which has no recognized number or letter, is marked Ru instead of R, Du instead of D, Va instead of V.

The mode of indicating star-magnitudes is new and altogether better, I think, than any before adopted. I had already made some progress with the mapping, using star-shaped figures, when it was suggested to me by two well-known astronomers that discs are preferable in an Atlas of this sort. But at first there was a difficulty as to the mode of indicating magnitudes. The present arrangement was suggested by Mr. Brothers, and struck me as so admirable in its simplicity and clearness that I at once determined to begin the work anew. It will be seen that the second, third, and fourth magnitudes are indicated respectively by two-pointed, three-pointed, and four-pointed centres. Stars of the first magnitude have a simple central disc; and so have stars of the fifth magnitude. There is, of course, no fear that a fifth magnitude star will be mistaken for one of the first magnitude. Stars of the sixth magnitude are simply black discs, while smaller stars are represented by smaller discs.

An important improvement, I think, consists in the adoption of Sir John Herschel's photometric scale of star-magnitudes as a guide in determining the scale of the discs of stars belonging to the three first orders of magnitude. The magnitudes hitherto given in maps are far from representing the true magnitudes of the stars; and, even did they do so, no star-maps can ever fairly represent the heavens, if means are not adopted for exhibiting the difference between the brightest and faintest stars of at least the leading magnitudes. Owing to the adoption of this plan, the present maps present the familiar star-groups in a manner which cannot but be far more satisfactory to those who study the heavens than the caricatures hitherto presented in our atlases.

I should like to see the constellation-figures wholly banished from Star-Atlases; but as these figures are too delightfully preposterous to be readily forsaken, I have so far yielded to the feeling in their favour as to let them appear in the index-plates.

The plan I have adopted for indicating the names of constellations is a manifest improvement on the one usually employed. The name of the constellation is read more easily, and at the same time (which is of far more importance) the star-groups are not disfigured by the presence of a number of letters straggling amongst them.

And here I approach with fear and trembling the subject of constellation nomenclature.

It has been the recognized practice of those who have drawn new Star-Atlases, to earn

a cheap immortality by adding new constellations to the heavens. According as these constellations are more or less preposterous, and as their names are more or less unwieldy, they appear to have had a greater or less chance of becoming fixtures in our atlases. Monoceros, Canes Venatici, and Cameleopardalis attest how clearly Hevelius recognized this great principle; while Bode has been even more strikingly successful in encumbering the heavens with such noteworthy additions as Honores Frederici, Globum Aerostaticum, and Machina Pneumatica. Again, the multitude of additions made by Lacaille to the southern heavens—Telescopium, Microscopium, Horologium, and whatever else is least celestial and most sesquipedal—if they roused a word of protest from practical Francis Baily, yet at once found a host of defenders among continental astronomers.

Therefore, if I had desired that my name should appear in the astronomical treatises of 2870 or 3870, I had nothing to do but to form some such constellations as *Tormentum Bellicum Whitworthiense*, or *Spectroscopium Automaticum Browningense*,* in the perfect assurance (derived from the long experience of astronomers) that these new constellations would be joyfully welcomed.

Instead of this, I have risked an immortality of objurgation by venturing on a small measure of reform. I have endeavoured to diminish the burden of names with which our maps have been encumbered.

Let me at once exhibit the full extent of my misdoing. I have altered—

Triangulum Boreale . . .	into	Triangula.
Triangulum Australe . . .	,,	Triangulum.
Canes Venatici	,,	Catuli.
Corona Borealis	,,	Corona.
Corona Australis	,,	Corolla.
Piscis Australis	,,	Piscis.
Cameleopardalis	,,	Camelus.
Vulpecula et Anser . . .	,,	Vulpes.
Equuleus	,,	Equus.
Delphinus	,,	Delphin.
Ursa Major	,,	Ursa.
Ursa Minor	,,	Minor.
Canis Major	,,	Canis.
Canis Minor	,,	Felis.
Leo Minor	,,	Leæna.
Monoceros	,,	Cervus.

In all 93 letters have been struck off these fifteen names, or 192 letters reduced to 99. I thought of doing away with Sagitta, altering Capricornus into Caper, and mulcting Sagittarius of a few letters,—but my heart failed me.

The Milky Way has been carefully copied from Sir John Herschel's picture, so far as the southern heavens are concerned. Elsewhere I have followed his description as closely as possible, here and there taking details from the best maps, and in some cases referring to the heavens themselves. This last course I found specially necessary in delineating the Milky Way around the gaps in Cygnus; and I was only prevented from applying it more frequently by the consideration that the aspect of the Milky Way must be regarded as a question of eyesight, and others may have seen the details of the galaxy more clearly than I have.

The precession-arrows marked in on the latitude-parallels serve to present the effects of precession much more intelligibly than any plan hitherto used. One can at once, by means of these arrows, tell the true place among the stars of any object whose R. A. and dec.

* The spectroscope of the future, *me judice.*

(or N. P. D.) are given for any date, even a hundred years before or after the date of the map. Remembering that all the stars are shifting (as respects their R. A. and dec.) parallel to the arrows, and that the nearest arrow to any star presents the star's precessional motion for 100 years (or, where the arrows differ most in length, that the extent of this motion lies between the lengths of the two nearest arrows), we can at once make any desired correction for precession. Thus, suppose we want to mark in an object whose R. A. and dec. are given for 1840, we find the stated place in the map, and put the star down in advance of that place, in the direction pointed out by neighbouring arrows, and by a distance equal to the length of two divisions out of five on the nearest arrow. And so all objects given for a date preceding 1880 may be marked in. Objects whose places are assigned for dates after 1880 will have, of course, to be shifted backwards to bring them into accordance with these maps. In all cases the change of place is parallel to the neighbouring latitude-parallels.

The map smay be regarded as appreciably true for the next thirty years; and available (owing to the simple way in which the correction for precession is made) for the next century or so.

It is to be noticed that, in passing from one map to another, there is no necessity for turning over map after map, as according to every plan hitherto adopted. One has only to look at the number of the map indicated outside the circumference, and to turn to that map. Looking round *its* circumference for the number of the map just left, one finds at once the continuation of the star-group under examination. For example, say one is studying Serpens in the lower left-hand corner of Map 8, and wishes to pass towards ψ and χ Scorpii. Map 9 is written outside the border, and turning to Map 9 one finds Map 8 written outside the upper right-hand border. There one finds the constellation Serpens, and its neighbours Ophiuchus, Scorpio, and Libra, as required.

The numbering of the maps is arranged on a very simple plan. The north polar map is numbered 1; the map whose central meridian marks 0^h R. A. is numbered 2; then the other equatorial maps, alternately south and north, in order of their right ascension; and, lastly, the south polar map is numbered 12.

Every precaution has been taken to make the maps as useful as possible to the observer. Many objects belonging to each of the various classes studied by astronomers have been introduced, while care has been taken to avoid encumbering the map with too many of these objects. Considering that most of these objects are employed (at present) rather as tests for telescopes than for original research, all that might have been deemed absolutely necessary was that enough of them should be marked in to supply the large army of amateur telescopists with that practice by which they seem to be preparing themselves for really useful researches in future years. However, as will be seen by what has been already written, I have gone far beyond this, insomuch that I suppose the total number of objects indicated in the twelve maps cannot fall very far short of two thousand.

But there is one purpose—hitherto wholly disregarded—which a Star-Atlas ought above all things to fulfil. It does not seem to have been hitherto considered that star-maps constructed on an intelligible plan, can supply most useful information respecting the laws of distribution and arrangement which exist among the stars. It is impossible for the unaided eye to recognize these laws even among the lucid stars, for reasons which every one who has studied the heavens will at once recognize. Star-maps, however, if well constructed, can give information as useful in its way as that which even the telescope can supply. They can render *palpable* laws which really exist, but escape all other modes of recognition.

Now that which has alone rendered the work of star-mapping congenial to my tastes, is the fact that it is in truth a method of research, and a method which is as yet new and untried. I did not complete the two sheets used as index-plates to this Atlas without recognizing the fact that systematic star-charting is a promising method of research; and I looked forward hopefully to the time when I should be able to extend the method to stars of the sixth magnitude. After four years of unavoidable delay, this became possible; and the progress of the

work has impressed on me most strikingly the value of this mode of research, viz., *the systematic charting of the heavens, on an intelligible plan by which the laws of stellar distribution and aggregation may be rendered obvious to the eye.* But the present Atlas is only a second step upon this new path. As my new theory of the sidereal system was suggested by the maps here used as index-plates, and many interesting peculiarities of stellar distribution by the larger maps, so I am certain that by extending the process successively to stars of the seventh, eighth, and ninth magnitudes, new facts of unimagined importance would be revealed. I do not hesitate to express my belief that if a hollow globe were constructed, on the dark inner surface of which * the 310,000 stars charted by Argelander should be shown, all the nebulæ yet discovered, the general results of the Herschels' star-gauges, the positions of red, variable, and other remarkable objects, and an accurate presentation of the Milky Way and the Magellanic Clouds, a far greater amount of light would be thrown on the relations presented by the sidereal system than could be obtained even by the use of a telescope twelve feet in aperture, conveniently mounted, driven accurately by clock-work, and supplied with the finest procurable spectroscopic appliances. For three centuries astronomers have been studying the heavens piecemeal; it is time that the scattered facts were brought together, and the heavens as interpreted by the telescope exhibited in one grand picture!

The information presented even by these maps, which advance so small a way into the celestial depths, is sufficiently promising to encourage high hopes of what might be done by applying a similar plan of research on a far wider scale.

In the first place, let me indicate the singularly disproportionate numbers of stars found in maps which each cover the same proportion of the heavens. Considering only the stars belonging to the British Association Catalogue (the professed object of that catalogue being to include all the stars visible to the naked eye), we have in the six northern and the six southern maps the following numbers :—

Northern Maps.				Southern Maps.			
1	contains	693	stars.	12	contains	1132	stars.
2	,,	397	,,	3	,,	523	,,
4	,,	526	,,	5	,,	834	,,
6	,,	415	,,	7	,,	547	,,
8	,,	390	,,	9	,,	595	,,
10	,,	563	,,	11	,,	528	,,
Total		2984		Total		4159	

Excess of stars in southern over stars in northern maps . . . 1175

Since each map covers one-tenth of the heavens instead of a twelfth, we shall not be far wrong if we take as the numbers falling within the true limits of the northern and southern maps respectively 2,487 and 3,466 stars.† This makes the excess of stars in the southern maps still nearly 1,000. The actual excess of visible stars in the southern *hemisphere* is rather more than 1,000; and it is only the overlapping of the equator by alternate maps which reduces the surplus.

Are not all the laws of probability against the existence of so remarkable a disproportion, save as the result of special laws of aggregation?

But looking more closely into the details of these numerical relations, we see that three

* The stars and other objects could be illuminated on the same principle as the "electric tree"; many batteries being employed. The whole construction would be an expensive affair; but the cost would be nothing compared with that of the Rosse reflector.

† That this is not far wrong is shown by the fact that the sum of these numbers (5,953) is only 21 beyond the actual number of stars extracted by me from the British Association Catalogue: of course the overlapping causes the difference.

maps stand markedly apart from the rest. First there is the south polar map with its array of 1,132 stars; then far behind the south polar map, but still far in advance of all others, comes Map 5 with 834 stars; then follows the north polar map with 693 stars, or 100 beyond the average. Map 9 has about the average number of stars; and all the remaining stars except three have a number not falling importantly below the average. These three maps (2, 6, and 8) contain between them but 1,202 stars, or but 70 more than the south polar map alone contains.*

Now it is only necessary to look at Maps 3 and 5 to see that there is (as we might feel certain beforehand from the nature of these numerical relations) a law of aggregation in the southern heavens. In these maps we recognize the boundary of a southern region rich in lucid stars. Less clearly, but still unmistakably, the outline of this rich region can be traced across Map 7. In Map 9 the boundary is irregular and straggling, and markedly associated with the peculiarities of the Milky Way. In Map 11 a very small portion of this rich region is seen trenching upon the lower left-hand part of the map. Map 12 is wholly occupied by this great region of stellar aggregation.

We notice further that the greater Magellanic Cloud occupies the very heart of this region; while the most cursory study of Map 12 will show how intimately the Magellanic Clouds are associated with the branching system of lucid stars extending through, or rather *forming*, the great southern rich region. It is also obvious, from the arrangement of the stars over the parts of the Milky Way shown in Map 5, Map 12, and Map 7, that large groups of lucid stars are intimately associated with the masses of minute orbs forming the Milky Way here.

In the northern heavens one recognizes a faint reflection of these relations. There is a tolerably well-marked, roughly circular, northern region, rich in stars, occupying the lower right-hand part of Map 1, traversing the upper left-hand corner of Map 2 (its boundary exceedingly well defined near Lacerta), and extending itself with straggling boundary over the upper right-hand portion of Map 10.

It is noteworthy that a single branch of the Milky Way joins the two regions, on one side, the complex part of the Milky Way joining the regions on the other side. Each of the rich regions includes a well-marked "coal-sack" in the galaxy, and corresponding to that projection which in the southern rich region the galaxy throws out from Carina towards the greater Magellanic Cloud, there is in the northern rich region the projection thrown out from Cepheus towards (Ursa) Minor.

It is also worthy of notice that the barest regions of the heavens are found on the borders of the rich regions, and along the edges of the Milky Way—notably in Cervus (Monoceros), and in that remarkably bare rift extending from Auriga past the feet of Gemini. One can recognize the prolongation of this bare region around the borders of the rich region in Map 1.

It may be also remarked, that all the well-marked star-streams recognized by the ancients—as Eridanus, Hydra, and the streams from the water-can of Aquarius—flow into the southern rich region.†

While drawing these maps, I have been struck by the manner in which red stars and variable stars are associated either with the Milky Way or with star-streams, and also by the frequent occurrence of streams in which are included lucid stars, red stars, variable stars, and conspicuous nebulæ. The fact that red stars, variables, and bright nebulæ are seldom (if at all) found alone in barren regions of great extent, is very significant; and by no means opposite in meaning to the fact noticed by Sir W. Herschel, that nebulæ begin to be found where star-groups end.

One other matter, of several which have suggested themselves while the work has been

* The first half of the south polar map contains more than 600 stars, while the first half of Map 8 contains but 150.

† The maps of the present series, photographed by Mr. Brothers, were used to illustrate my lecture on "Star-grouping, Star-Drift, and Star-Mist," delivered at the Royal Institution on May 6th. I think every one who saw them must have felt how much of their effect was due to the skill with which they had been photographed, the blackness of the background being most striking.

in progress, seems to merit a word of comment. I think I have detected the plan on which the ancient astronomers associated the constellation-figures with star-groups. By ancient astronomers I refer, of course, to those compared with whom Ptolemy and Hipparchus are moderns.

It must have struck every one who has compared star-groups and the figures with which they are associated, that no resemblance can be recognized save in one or two instances. Now in drawing Map 6, I was very much struck by the resemblance between a star-grouping covering a large proportion of the map and the figure of a lion. This resemblance has become less striking since constellation-outlines and names, besides double stars and nebulæ not visible to the naked eye, have been added. But I think it can still be clearly recognized. I find in the stars covering the northern part of Cancer (α, λ, σ, &c.) the *head* of this lion, in the stream of stars from λ Ursæ to 54 Leonis the *outline of the mane* (blown back as though the animal were leaping through the air, as we might conceive a lion leaping upon the folds of the Chaldæan shepherds who were the first astronomers), the *fore-limbs* in the group of stars covering the southern part of Cancer and the head of Hydra, the *hind-limbs* partly shown in the lower left-hand part of the map, the *hind-quarters* covering the quadrilateral formed by the stars δ, θ, β, and 93 Leonis, and the *tail* terminating in the stars which form the constellation Coma. Now it seems clear to me that the southern claw of the Crab, as originally recognized by astronomers, occupied the region I have here assigned to the head of Leo, while the southern claw occupied the region now occupied by the head of Hydra. And the general principle I enunciate is this, that—

The ancient astronomers, in forming a constellation, did not follow the plan adopted in comparatively modern times by Ptolemy, of causing each constellation to occupy its own definite portion of the heavens; but considered each group independently, whether it overlapped some other group or not.

Many illustrative instances will be found in other maps, and more would doubtless be recognized on a well-constructed globe, showing the stars only on a black background. I may mention, amongst other cases found within these maps, the constellation Serpens, which I think must originally have extended over Corona. I fancy too that Corona formed the uplifted arm of Boötes. Clearly also the poop of the great ship Argo covered the region now occupied by the hind-quarters of Canis.

The subject is far from being trivial, since, if no resemblance could be traced between star-groups and the ancient constellation-figures, the startling idea would be suggested that among whole groups of stars there had been changes of lustre, stars waxing here and waning there, so that the whole aspect of the groups had changed in the few thousand years which have elapsed since the ancient constellation-figures were first recognized.

RICHARD A. PROCTOR.

London, *May* 30*th*, 1870.

LIST OF CONSTELLATIONS,

AND

NAMES OF THE PRINCIPAL STARS.

Andromeda. (Map 2.)

α. Alpheratz.
β. Mizar, Mirach.
γ. Almaach.

Antlia. (Map 7.)

Apus. (Map 12.)

Aquarius. (Map 11.)

α. Sadalmelik.
β. Sadalsuud.
γ. Sadachbia.

Aquila. (Map. 10.)

α. Altair.
β. Alshain.
γ. Tarazed.

Ara. (Map 9.)

Argo. (Map 5.)
(*Carina, Malus, Puppis, Vela.*)

α. Canopus.
ι. Tureis.

Aries. (Map 4.)

α. Hamal.
β and γ. Sheratain.
γ. Mesarthim.

Auriga. (Map 4.)

α. Capella.
β. Menkalinan.
γ. Hab' dhú-l'-inan.
ζ. Sadatoni.

Bootes. (Map 8.)

α. Arcturus.
β. Nekkar.
ε. Izar, Mizar, Mirac.
η. Saak.
μ. Alkaturops.

Cælum. (Map 3.)

Cameleopardalis, *seu* **Camelus.** (Map 1.)

Cancer. (Map 6.)

α. Al Hamarein.
γ and δ. Aselli, Onoi.
ζ. Tegmine.
44 M. Præsepe.

Canes Venatici, *seu* **Catuli.** (Map 8.)

α. Cor Caroli.

Canis Major, *seu* **Canis.** (Map 5.)

α. Sirius.
β. Mirzam.
δ. Wezen.
ε. Adara.
ζ. Phurûd.
η. Aludra.

Canis Minor, *seu* **Felis.** (Map 5.)

α. Procyon.
β. Gomeisa.
γ. Isis.

Capricornus. (Map 11.)

α and β. Sa'd-adh-dhabih.
γ. Deneb Algedi.

Cassiopeia. (Map 1.)

α. Schedir.
β. Chaph.

Centaurus. (Map 7.)

Cepheus. (Map 1.)

α. Alderamin.
β. Alphirk.
γ. Alrai.

Cetus. (Map 3.)

α. Menkar.
β. Diphda.
γ. Kaff-al-jidhina.
ζ. Baten-Kaitos.
η. Dheneb.
ι. Dheneb-Kaitos.
ο. Mira.

Chamæleon. (Map 12.)

Circinus. (Map 12.)

Columba. (Map 5.)

α & β. Hadar, Mulipheim.
β. Wezn.

Coma, *seu* **Coma Berenices.** (Map 8.)

Corona Australis, *seu* **Corolla.** (Map 9.)

Cor. Borealis, *seu* **Corona.** (Map 8.)

α. Gemma, Alphecca.

Corvus. (Map 7.)

α. Minkár.
δ. Alchiba, Algorab.

Crater. (Map 7.)

α. Alkes.

Crux. (Map 12.)

Cygnus. (Map 10.)

α. Arided, Deneb-Adige.
β. Albireo.
π. Azelfafage.

Delphinus, *seu* **Delphin.** (Map 10.)

α. Svalocin.*
β. Rotanev.*

Dorado. (Map 12.)

Draco. (Map 1.)

α. Thuban.
β. Alwaid.
γ. Etanim.
δ. Taïs.
λ. Júza.
μ. Arrakis.

Equuleus, *seu* **Equus.** (Map 11.)

α. Aourin.

Eridanus. (Map 3.)

α. Achernar.
β. Cursa.
γ. Zaurak.
ο. Beïd.
40. Keid.

Fornax. (Map 3.)

Gemini. (Map 6.)

α. Castor.
β. Pollux.
γ. Alhena.
δ. Wasat.
ε. Mebsuta.
μ. Tejat.

Grus. (Map 11.)

* These names, which have no meaning as they stand, and have caused some perplexity on that account to the learned, seem to be simply the inversion of the name "Nicolaus Venator."

Hercules. (Map 10.)

α. Ras Algethi.
β. Korneforos.
λ. Masym.

Horologium. (Map 3.)

Hydra. (Map 7.)

α. Alphard, Cor Hydræ.

Hydrus. (Map 12.)

Indus. (Map 11.)

Lacerta. (Map 2.)

Leo. (Map 6.)

α. Regulus, Cor Leonis.
β. Denebola.
γ. Algeiba.
δ. Zosma.
μ. Rasalas.

Leo Minor, *seu* **Leæna.** (Map 6.)

Lepus. (Map 5.)

α. Arneb.

Libra. (Map 9.)

α. Phact.

Lupus. (Map 9.)

Lynx. (Map 6.)

Lyra. (Map 10.)

α. Vega.
β. Sheliak.
γ. Sulaphat.

Mensa. (Map 12.)

Microscopium. (Map 11.)

Monoceros, *seu* **Cervus.** (Map 5.)

Musca. (Map 12.)

Norma. (Map 9.)

Octans. (Map 12.)

Ophiuchus. (Map 9.)

α. Ras al ague.
β. Celbalrai.
η. Sábik.

Orion. (Map 4.)

α. Mirzam, Betelgeuse.
β. Rigel.
γ. Bellatrix.
δ. Mintaka.
ε. Alnilam.
ζ. Alnitak.
λ. Heka.

Pavo. (Map 12.)

Pegasus. (Map 2.)

α. Markab.
β. Scheat.
γ. Algenib.
ε. Enif.
ζ. Homan.

Perseus. (Map 4.)

α. Mirfak.
β. Algol.

Phœnix. (Map 3.)

Pictor. (Map 5.)

Pisces. (Map 2.)

α. Kaïtaïn.

Piscis, *seu* **Piscis Australis.** (Map 11.)

α. Fomalhaut.

Reticulum. (Map 12.)

Sagitta. (Map 10.)

Sagittarius. (Map 9.)

ε. Kaus Australis.

Scorpio. (Map 9.)

α. Antares, Cor Scorpionis.
β. Akrab.
λ. Sháulah, Lesath.

Sculptor. (Map 11.)

Serpens. (Map 9.)

α. Cor Serpentis.
θ. Alya.

Sextans. (Map 6.)

Taurus. (Map 4.)

α. Aldebaran.
β. Nath.
γ. Hyadum Primus.

The Pleiades.

23.	Merope.
η *Tauri.*	Alcyone.
129. P. III.	Celæno.
130. P. III.	Electra.
19.	Taÿgeta.
	Asterope.
	Maia.

Telescopium. (Map 9.)

Toucan. (Map 12.)

Triangulum Australe, *seu* **Triangulum.** (Map 12.)

Triangulum Boreale, *seu* **Triangula.** (Map 2.)

Ursa Major, *seu* **Ursa.** (Map 1.)

α. Dubhe.
β. Mirak.
γ. Phecda.
δ. Megrez.
ε. Alioth.
ζ. Alcor, Mizar.
ζ (*comes of*). Suhà.
η. Alkaid, Benetnasch.
ι. Talitha.

Ursa Minor, *seu* **Minor.** (Map 1.)

α. Polaris, Alruccabah.
β. Kocab.
η. Alasco.

Virgo. (Map 7.)

α. Spica.
β. Zavijava.
γ. Porrima.
ε. Vindemiatrix.
ι. Syrma.

Volans. (Map 12.)

Vulpecula, *seu* **Vulpes.** (Map 10.)

I.
NORTHERN
CONSTELLATIONS.

E.A. Procter del.

London

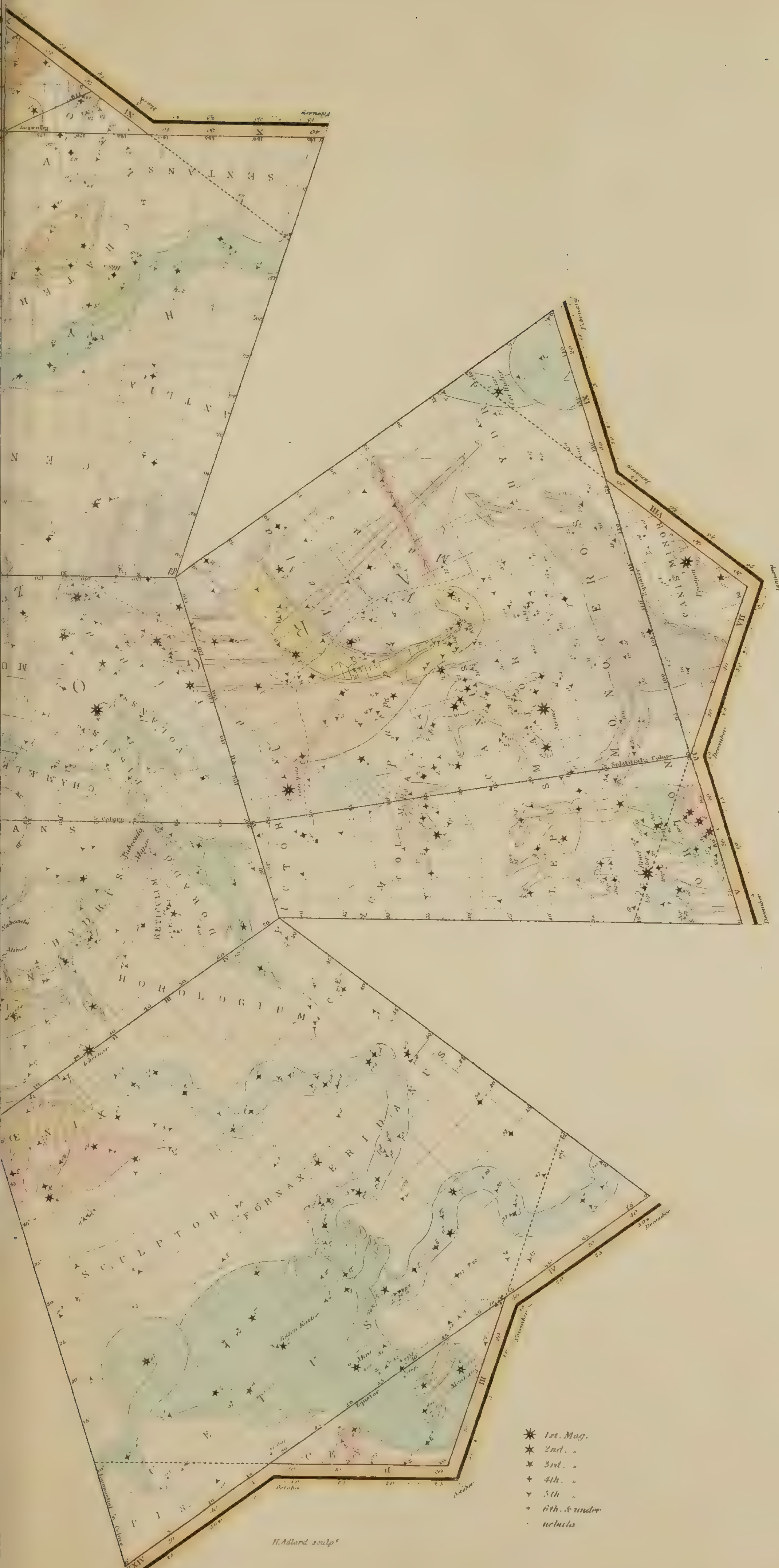
1880.


LACERTA
DELPHINUS
Solstitial Colure
1st Mag.
2nd
3rd
4th
5th
6th, & under
nebula
H. Adlard sculpt

mans & Co.

II.
SOUTHERN
CONSTELLATIONS.

1880.

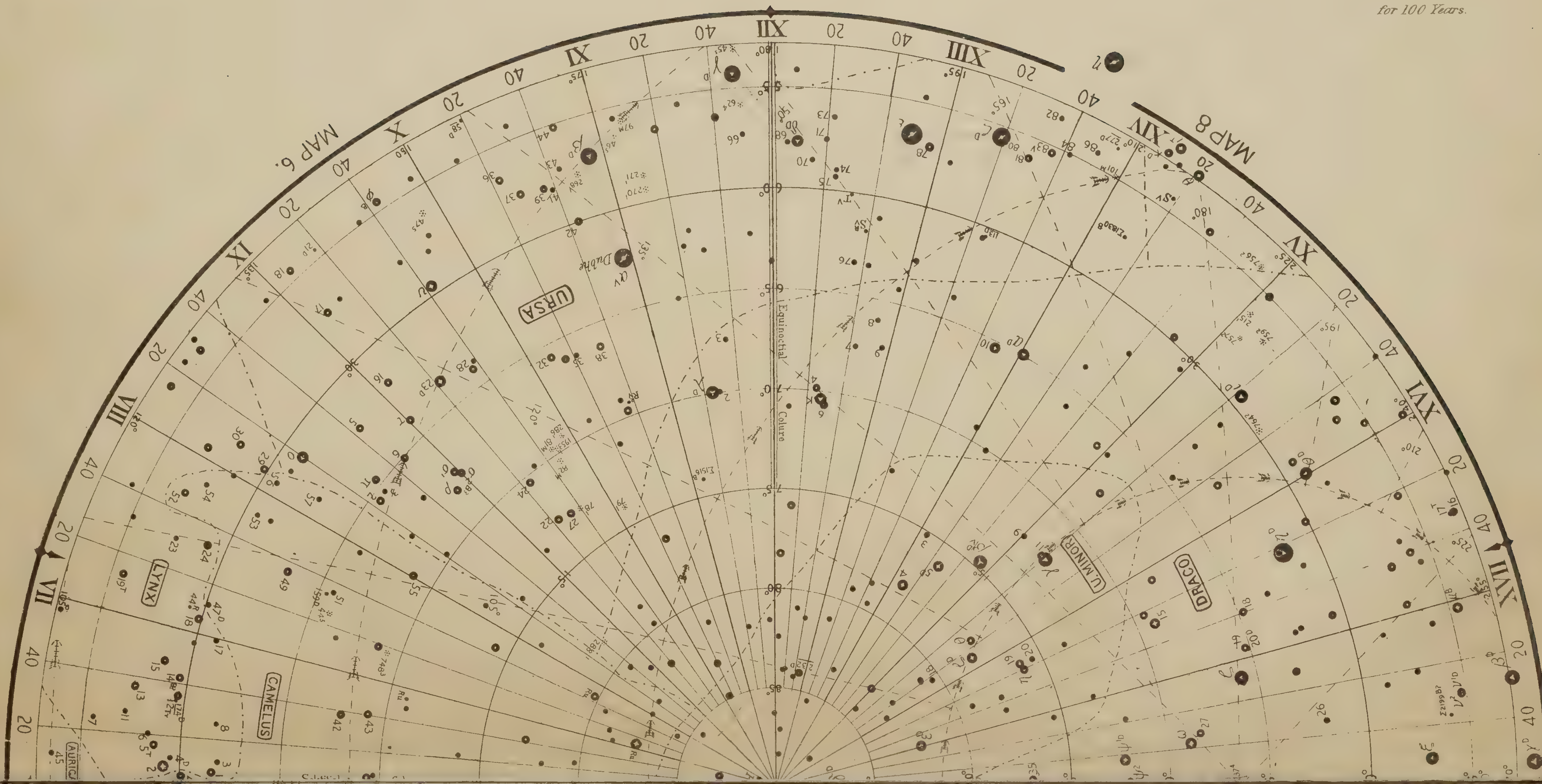

SEXTANS
ANTLIA
HYDRA
HOROLOGIUM
RETICULUM
SCULPTOR
FORNAX
ERIDANUS
CETUS
PISCES
LEPUS
Solstitial Colure
Equator
1st. Mag.
2nd.
3rd.
4th.
5th
6th. & under
nebula
H. Adlard sculp.

an & Co

MAP I.

ANNO 1880.

The arrows indicate the precessional motion for 100 Years.



MAP 2.

R. A. PROCTOR *Del.t*

A. BROTHERS. *Photo Litho.*

STAR MAGNITUDES.

- to — *FIRST.*
- to — *SECOND.*
- to — *THIRD.*
- *FOURTH.*
- *FIFTH.*
- *SIXTH.*
- *SEVENTH.* *(and under)*
- *NEBULA.*

ABBREVIATIONS.

R or Ru — *Red*	Tr — *Trinary*
V or Va — *Variable*	21 — 21 *Piazzi*
D or Du — *Double*	Σ — *Struve*
T — *Triple*	Δ — *Dunlop*
Qa — *Quadruple*	H — *Sir W. Herschel*
Qi — *Quintuple*	h — *Sir J. Herschel*
B — *Binary*	

B? — *Suspected Binary*

M *(to a Star)* — *Multiple*

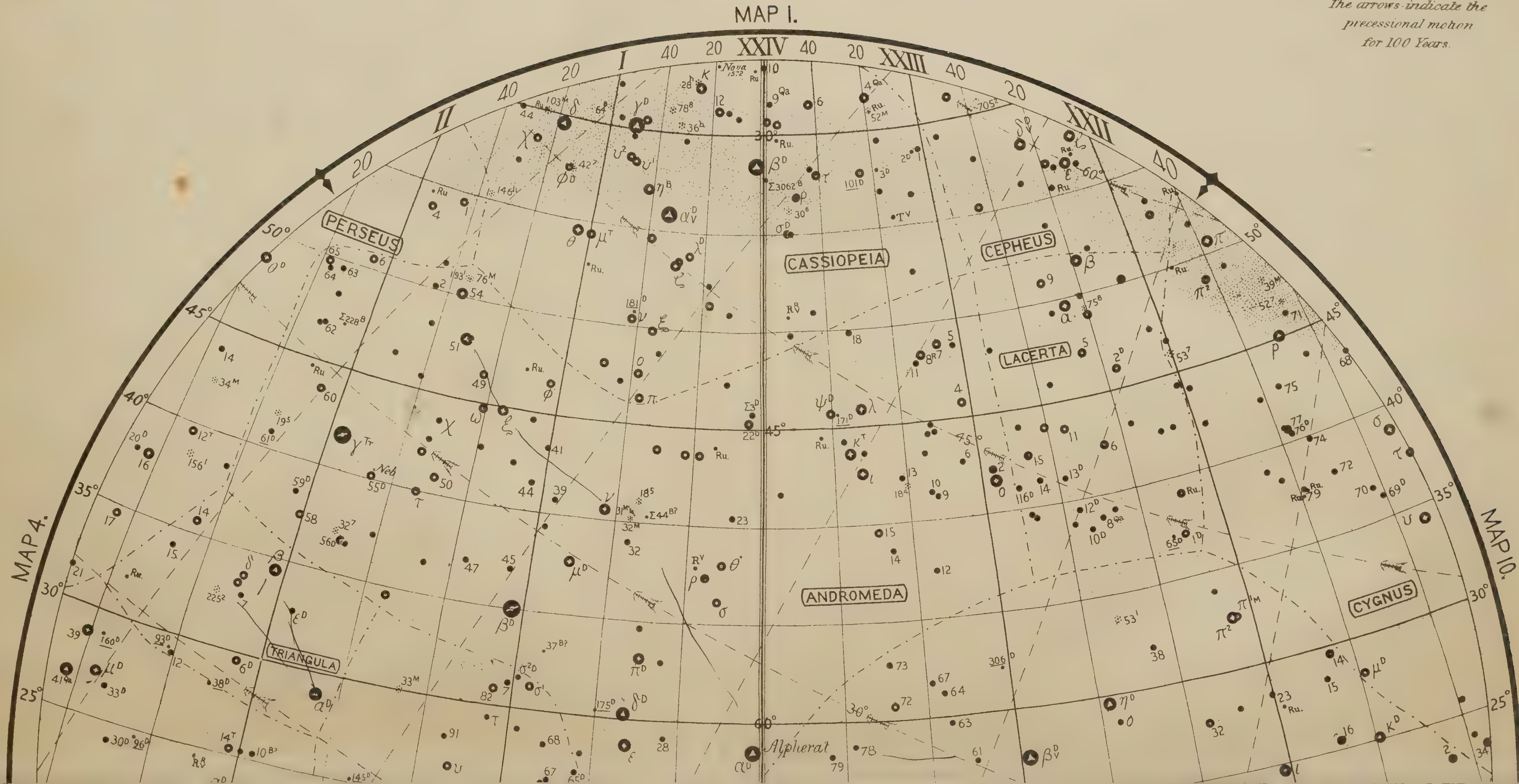
M *(to a nebula)* — *Messier*

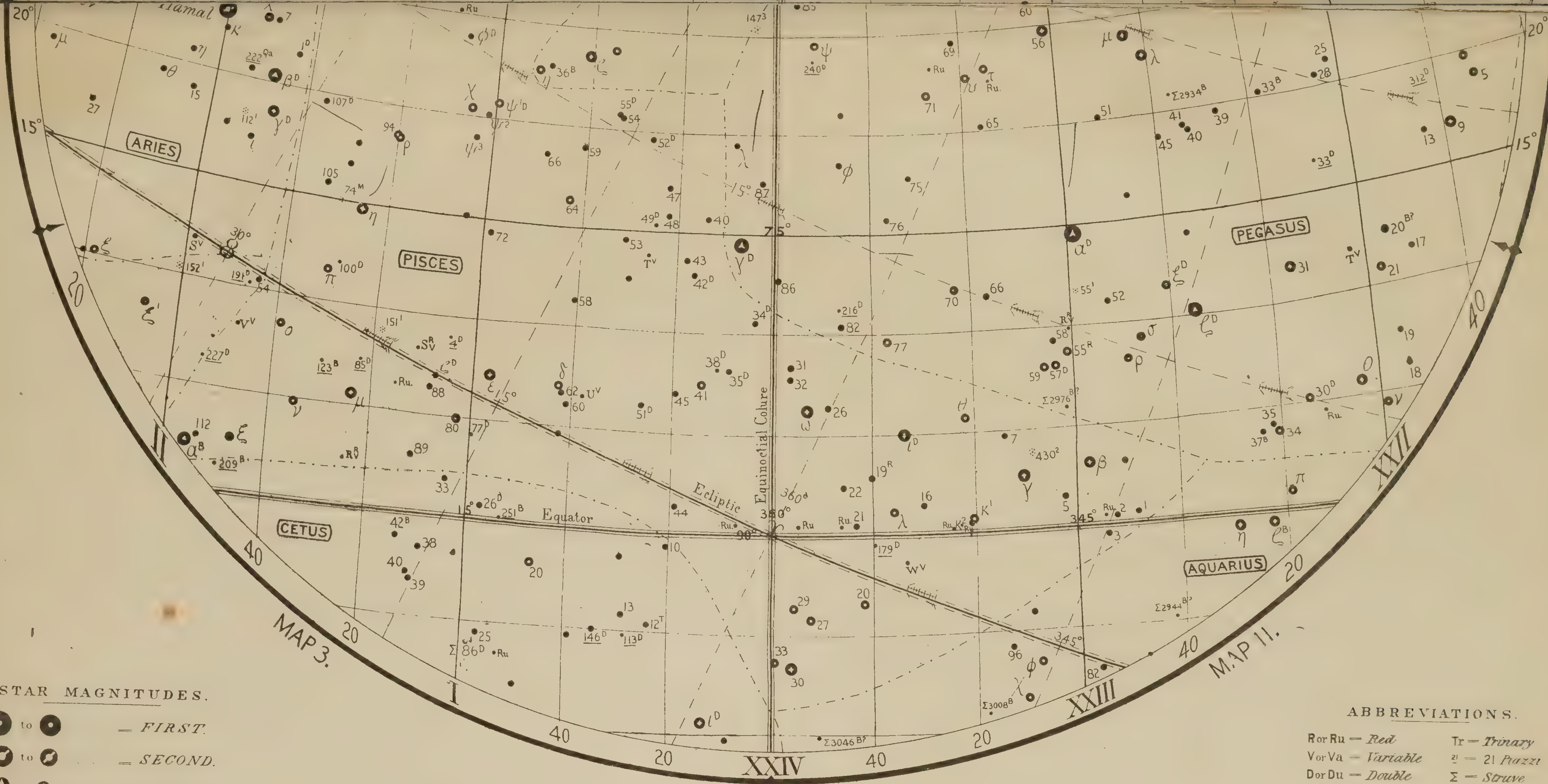
10^5 *(to a nebula)* — H. V. 10

MAP 2.

ANNO 1880.

The arrows indicate the precessional motion for 100 Years.





STAR MAGNITUDES.

to — FIRST.
to — SECOND.
to — THIRD.
— FOURTH.
— FIFTH.
— SIXTH.
— SEVENTH. (and under)
NEBULA.

R.A.PROCTOR, *Delt.*

A.BROTHERS *Photo Litho.*

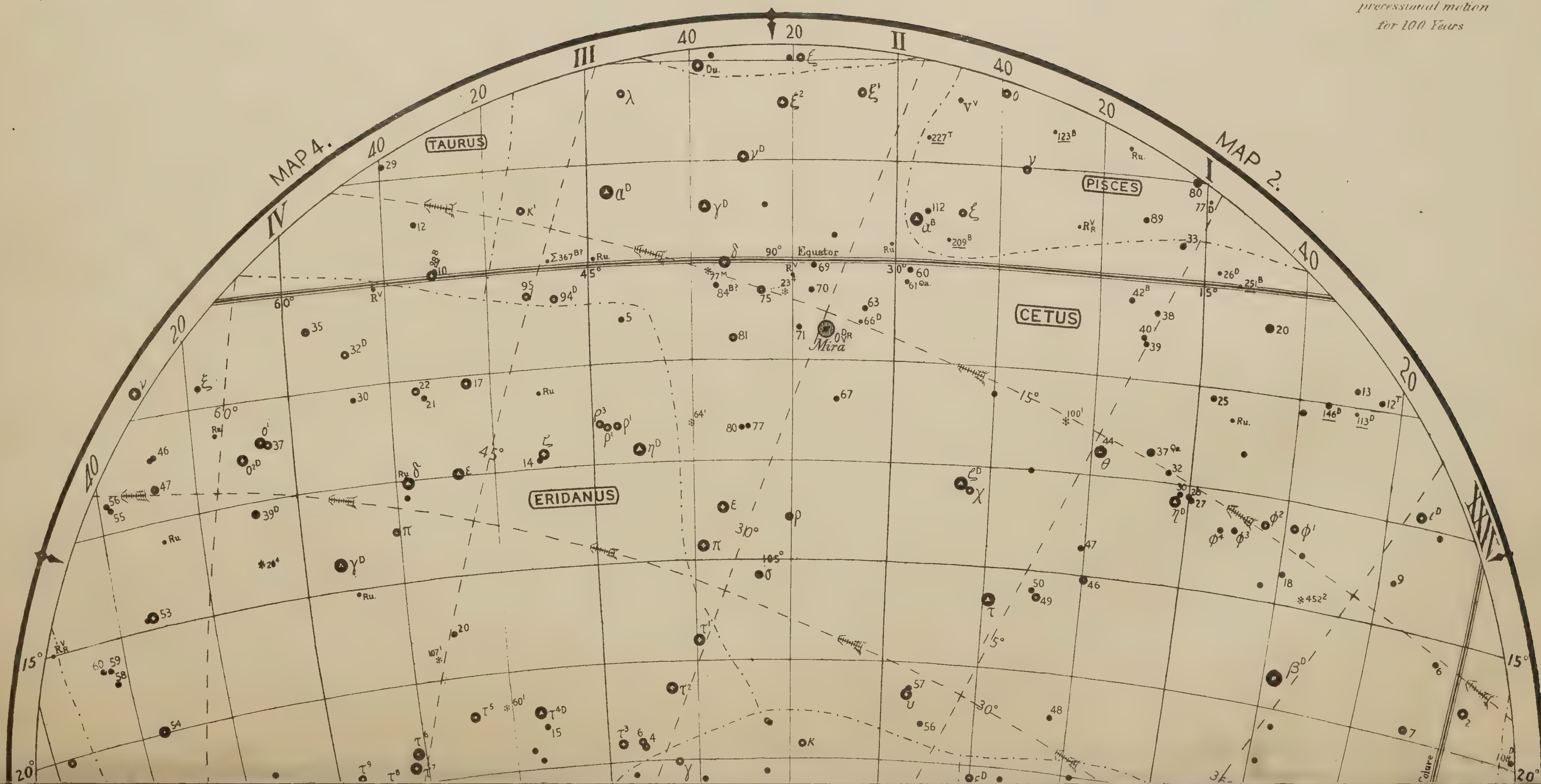
ABBREVIATIONS.

R or Ru — *Red*
V or Va — *Variable*
D or Du — *Double*
T — *Triple*
Qa — *Quadruple*
Qi — *Quintuple*
B — *Binary*
B? — *Suspected Binary*
M (*to a Star*) — *Multiple*
M (*to a nebula*) — *Messier*
10⁵ (*to a nebula*) — H. V. 10.
Tr — *Trinary*
21 — 21 *Piazzi*
Σ — *Struve*
Δ — *Dunlop*
H — *Sir W. Herschel*
h — *Sir J. Herschel*

MAP 3.

ANNO 1880.

The arrows indicate the precessional motion for 100 Years



MAP 12.

R A PROCTOR.

A. BROTHERS. Photo Litho

STAR MAGNITUDES.

to — FIRST.
to — SECOND.
to — THIRD.
= FOURTH.
= FIFTH.
= SIXTH.
= SEVENTH 'and under'
NEBULA.

ABBREVIATIONS.

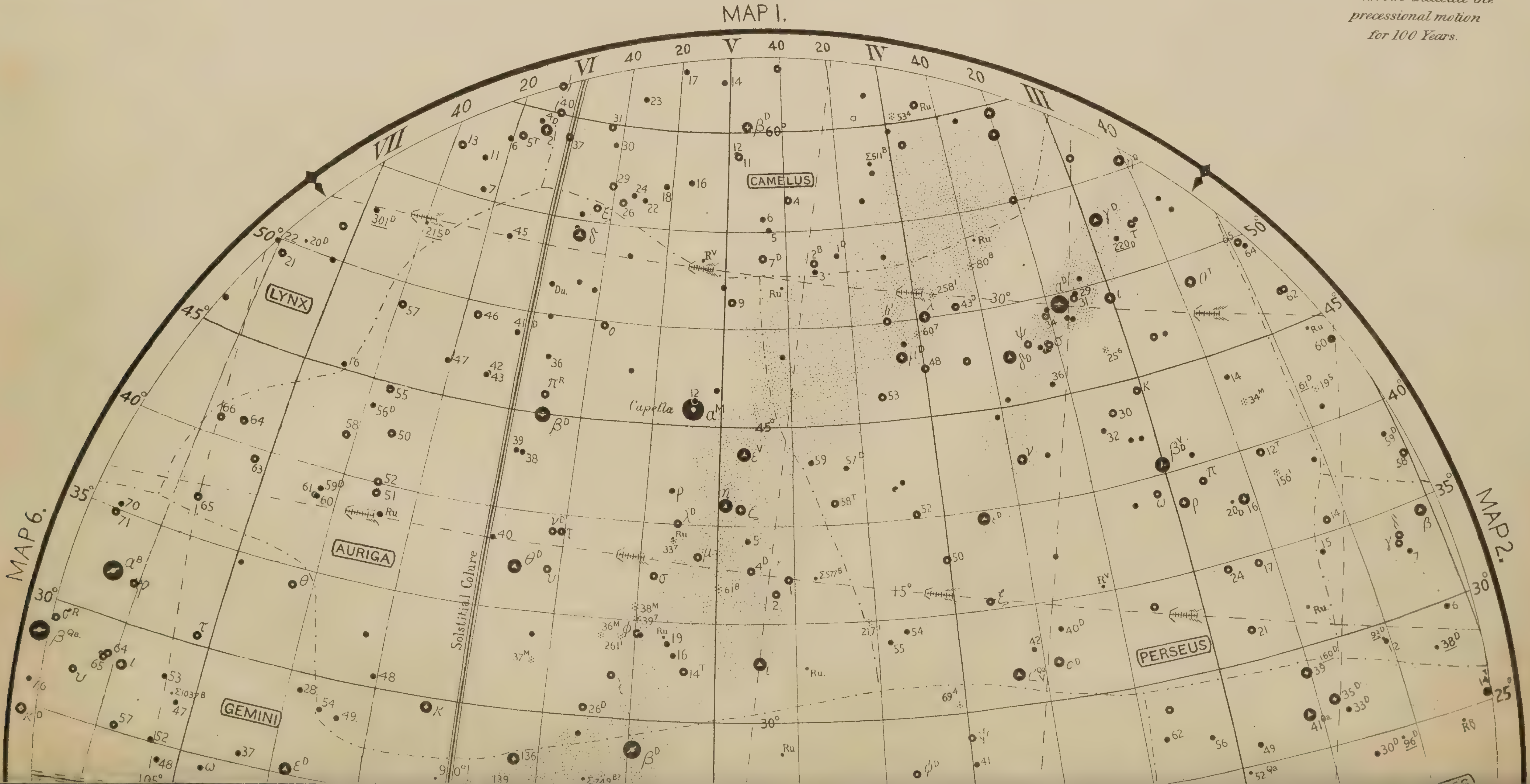
R or Ru — *Red*
V or Va — *Variable*
D or Du — *Double*
T — *Triple*
Qa — *Quadruple*
Qi — *Quintuple*
B — *Binary*
Tr — *Trinary*
21 — 21 *Piazzi*
Σ — *Struve*
Δ — *Dunlop*
H — *Sir W. Herschel*
h — *Sir J. Herschel*
B? — *Suspected Binary*
M (*to a Star*) — *Multiple*
M (*to a nebula*) — *Messier*
10^5 (*to a nebula*) — H. V. 10.

TAURUS
ORION
ERIDANUS
CETUS
CERVUS
Aldebaran
Betelgeux
Rigel
Pleiades
Ecliptic
Equator
MAP 5.
MAP 3.
STAR MAGNITUDES.
to — FIRST.
to — SECOND.
to — THIRD.
— FOURTH.
— FIFTH.
— SIXTH.
— SEVENTH. (and under)
NEBULA.
ABBREVIATIONS.
R or Ru — Red
V or Va — Variable
D or Du — Double
T — Triple
Qa — Quadruple
Qi — Quintuple
B — Binary
B? — Suspected Binary
M (to a Star) — Multiple
M (to a nebula) — Messier
10⁵ (to a nebula) — H. V. 10.
Tr — Trinary
21 — 21 Piazzi
Σ — Struve
Δ — Dunlop
H — Sir W. Herschel
h — Sir J. Herschel
R. A. PROCTOR, Delt.
A. BROTHERS, Photo Litho

MAP 4.

ANNO 1880.

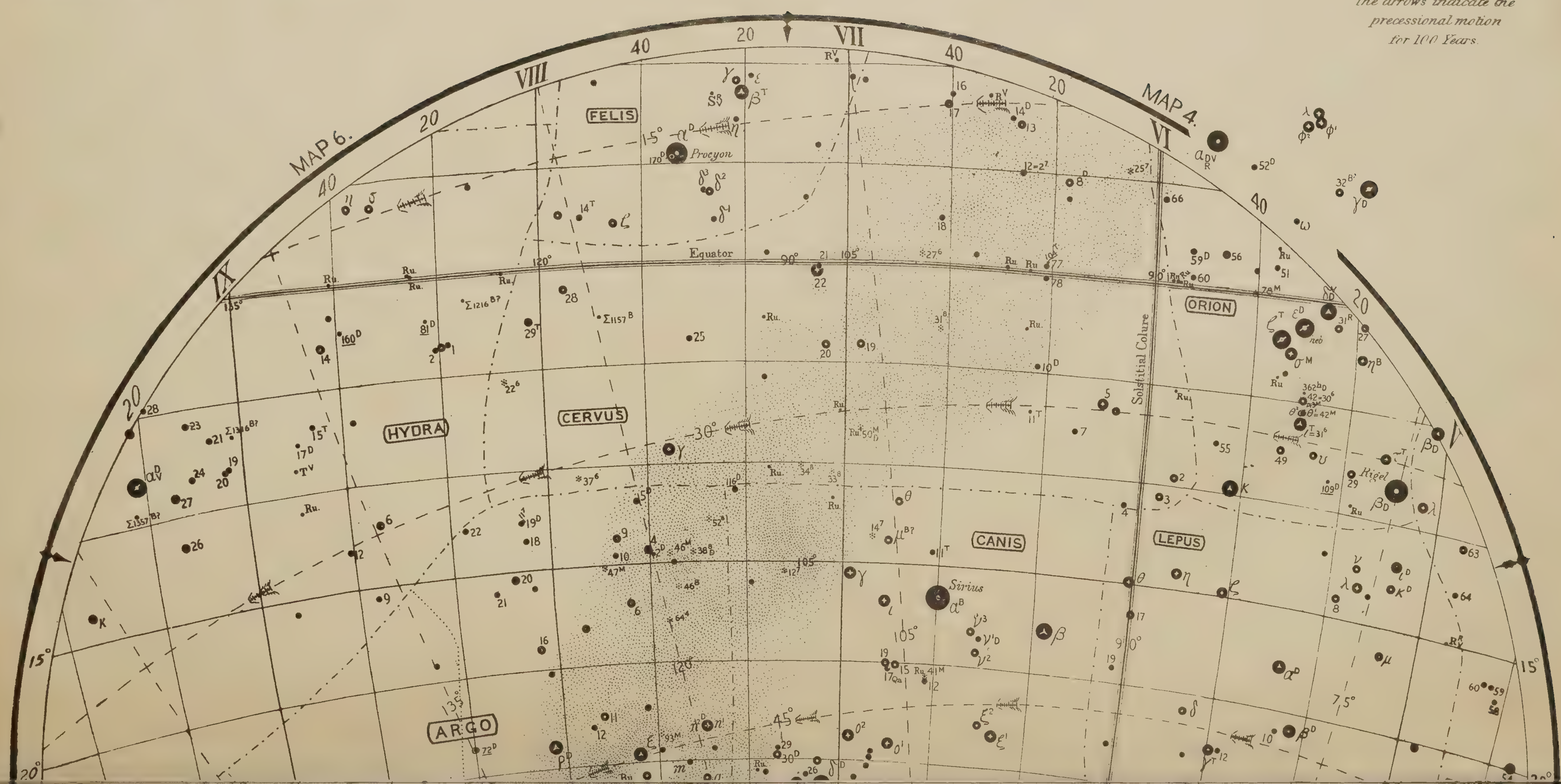
The arrows indicate the precessional motion for 100 Years.

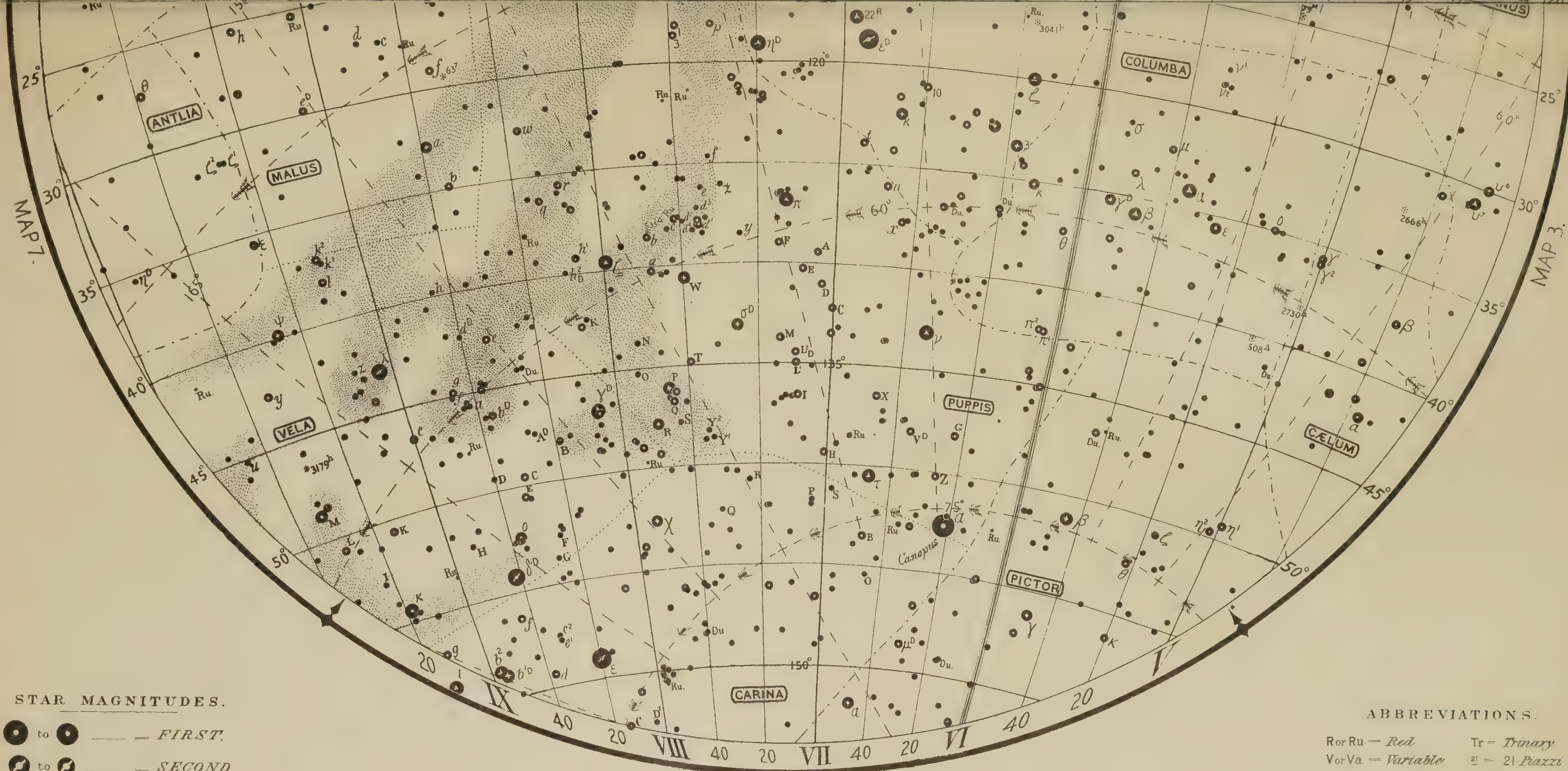


MAP 5.

ANNO 1880.

The arrows indicate the precessional motion for 100 Years.





MAP 12

R A. PROCTOR Del.t

A. BROTHERS. Photo Litho.

STAR MAGNITUDES.

to — FIRST.
to — SECOND.
to — THIRD.
— FOURTH.
— FIFTH.
— SIXTH.
— SEVENTH. and under.
NEBULA.

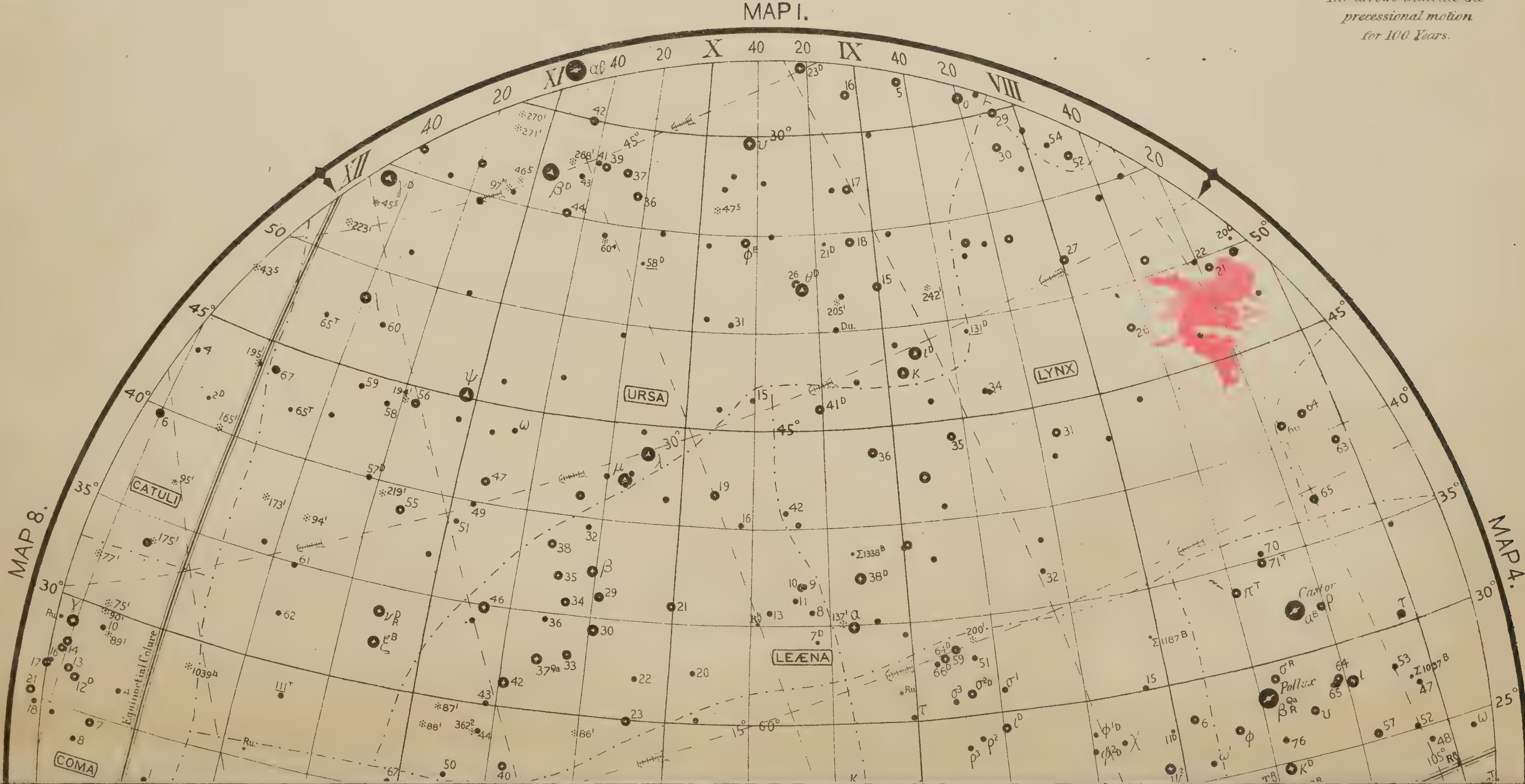
ABBREVIATIONS.

R or Ru — Red
V or Va — Variable
D or Du — Double
T — Triple
Qa — Quadruple
Qi — Quintuple
B — Binary
B? — Suspected Binary
M (to a Star) — Multiple
M (to a nebula) — Messier
10^5 (to a nebula) — H. V. 10
Tr — Trinary
^{21} — 21 Piazzi
Σ — Struve
Δ — Dunlop
H — Sir W Herschel
h — Sir J Herschel

MAP 6.

ANNO 1880.

The arrows indicate the precessional motion for 100 Years.

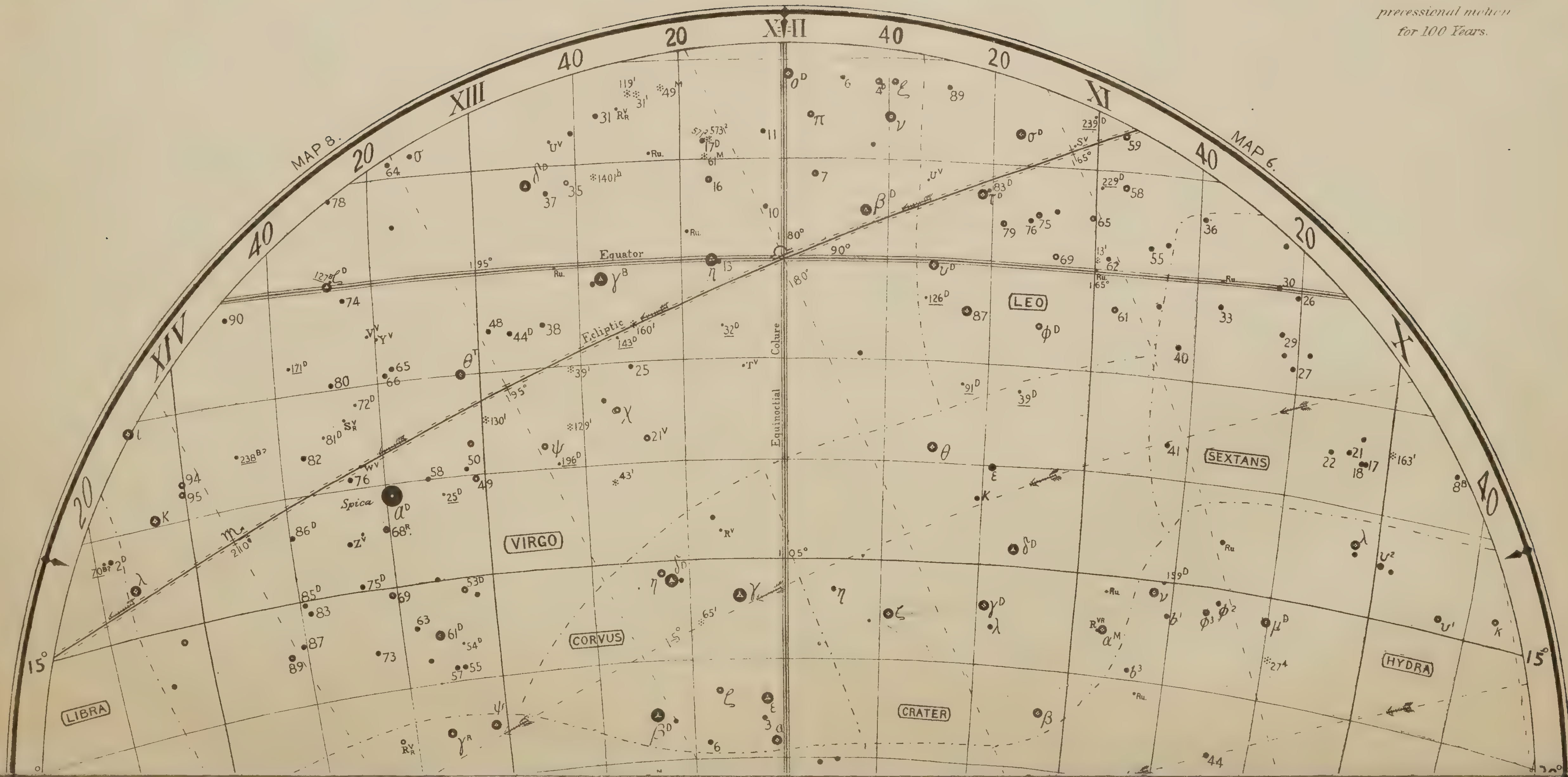



CANCER
GEMINI
LEO
VIRGO
FELIS
HYDRA
SEXTANS
Procyon
Ecliptic
Equator
MAP 5.
MAP 7.
VIII
IX
X
XI
XII
STAR MAGNITUDES.
to — FIRST.
to — SECOND.
to — THIRD.
— FOURTH.
— FIFTH.
— SIXTH.
— SEVENTH. (and under)
NEBULA.
ABBREVIATIONS.
R or Ru — Red
V or Va — Variable
D or Du — Double
T — Triple
Qa — Quadruple
Qi — Quintuple
B — Binary
Tr — Trinary
21 — 21 Piazzi
Σ — Struve
Δ — Dunlop
H — Sir W. Herschel
h — Sir J. Herschel
B: Suspected Binary
M (to a Star) Multiple
M (to a nebula) — Messier
10⁵ (to a nebula) — H. V. 10.
R.A. PROCTOR. Delt.
A BROTHERS. Phot. Litho.

MAP 7.

ANNO 1880.

The arrows indicate the precessional motion for 100 Years.



MAP 12.

R.A.PROCTOR. *Del.t*

A.BROTHERS. *Photo Litho.*

STAR MAGNITUDES.

to	— *FIRST.*
to	— *SECOND.*
to	— *THIRD.*
	— *FOURTH.*
	— *FIFTH.*
	— *SIXTH.*
	— *SEVENTH.* (and under)
	NEBULA.

ABBREVIATIONS

R or Ru	— *Red*	Tr	— *Trinary*
V or Va	— *Variable*	21	— 21 *Piazzi*
D or Du	— *Double*	Σ	— *Struve*
T	— *Triple*	Δ	— *Dunlop*
Qa	— *Quadruple*	H	— *Sir W. Herschel*
Qi	— *Quintuple*	h	— *Sir J. Herschel*
B	— *Binary*		

B? — *Suspected Binary*

M (*to a Star*) — *Multiple*

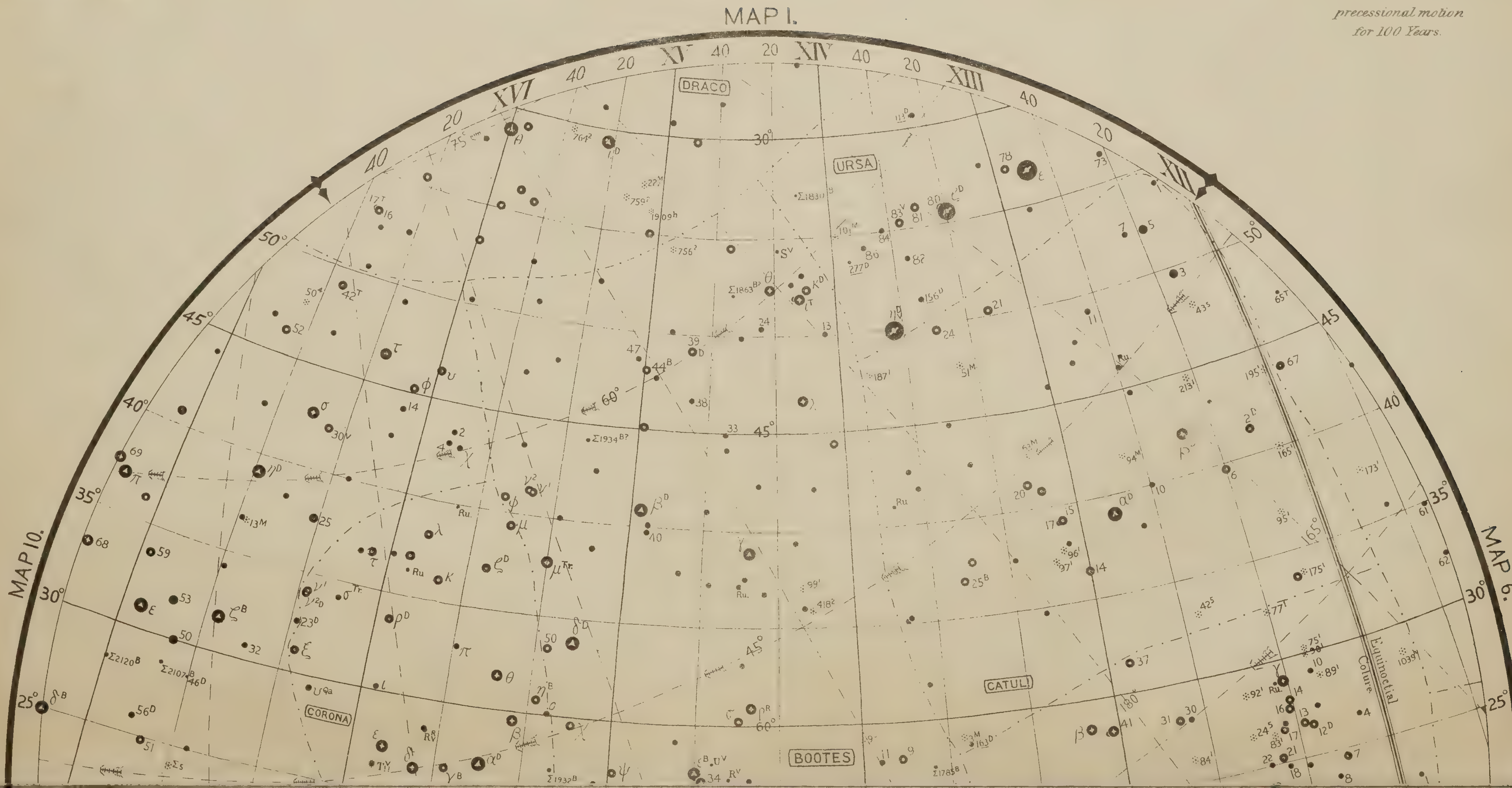
M (*to a nebula*) — *Messier*

10⁵ (*to a nebula*) — H.V. 10.

MAP 8.

ANNO 1880.

The arrows indicate the precessional motion for 100 Years.



STAR MAGNITUDES.

to	— FIRST.
to	— SECOND.
to	— THIRD.
	— FOURTH.
	— FIFTH.
	— SIXTH.
	— SEVENTH. (and under)
	NEBULA.

R A PROCTOR. *Del.*

A BROTHERS. *Photo Litho.*

ABBREVIATIONS.

R or Ru — *Red*	Tr — *Trinary*
V or Va — *Variable*	21 — 21 *Piazzi*
D or Du — *Double*	Σ — *Struve*
T — *Triple*	Δ — *Dunlop*
Qa — *Quadruple*	H — *Sir W. Herschel*
Qi — *Quintuple*	h — *Sir J. Herschel*
B — *Binary*	

B? — *Suspected Binary*

M (*to a Star*) — *Multiple*

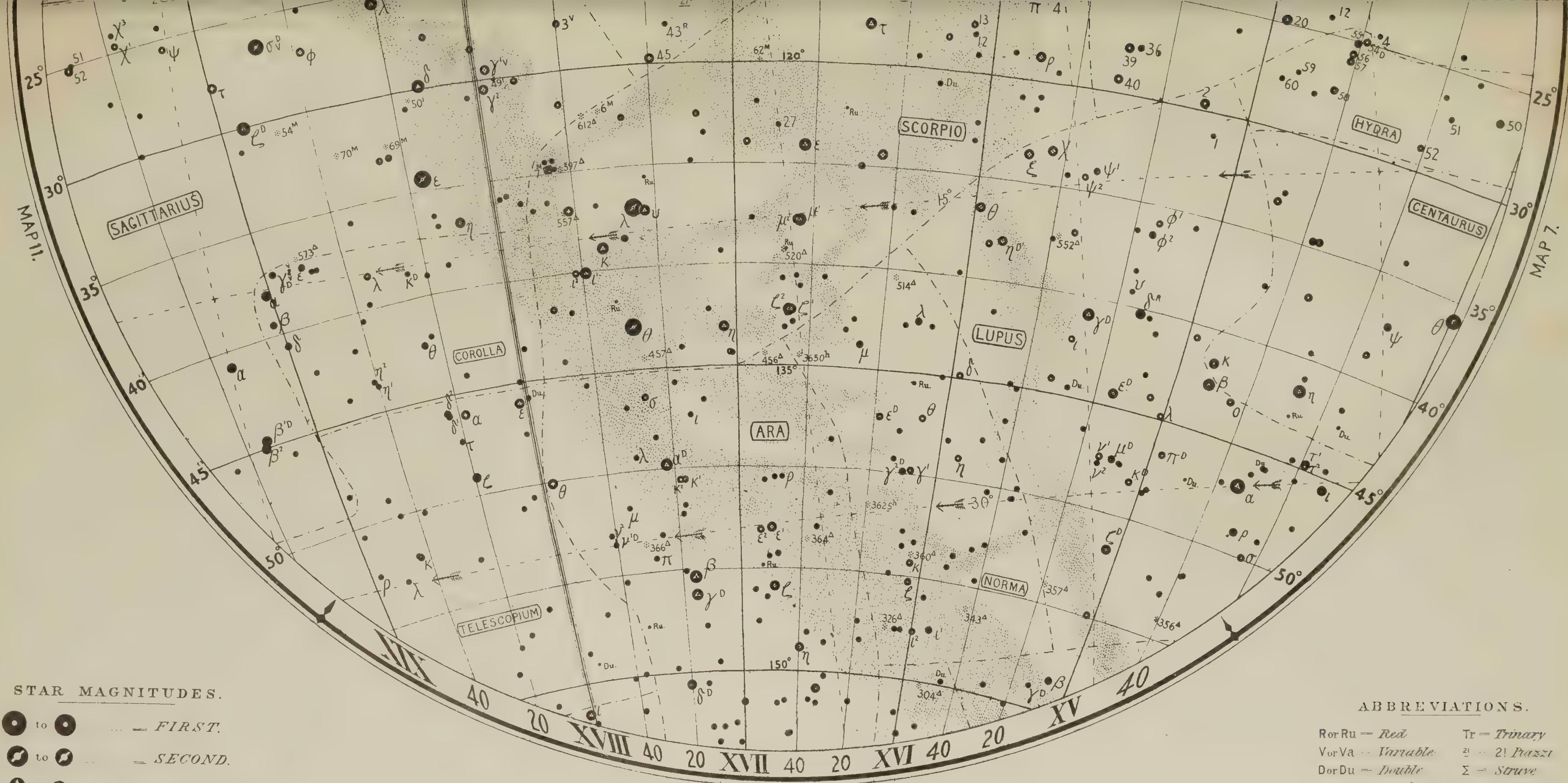
M (*to a nebula*) — *Messier*

10^5 (*to a nebula*) — H. V. 10.

MAP 9.

ANNO 1880.

The arrows indicate the precessional motion for 100 Years.



MAP 12.

R.A.PROCTOR. Delt.

A.BROTHERS. *Photo Litho*

STAR MAGNITUDES.

to	— *FIRST.*
to	— *SECOND.*
to	— *THIRD.*
	— *FOURTH.*
	— *FIFTH.*
	— *SIXTH.*
	— *SEVENTH.* (and under)
	NEBULA.

ABBREVIATIONS.

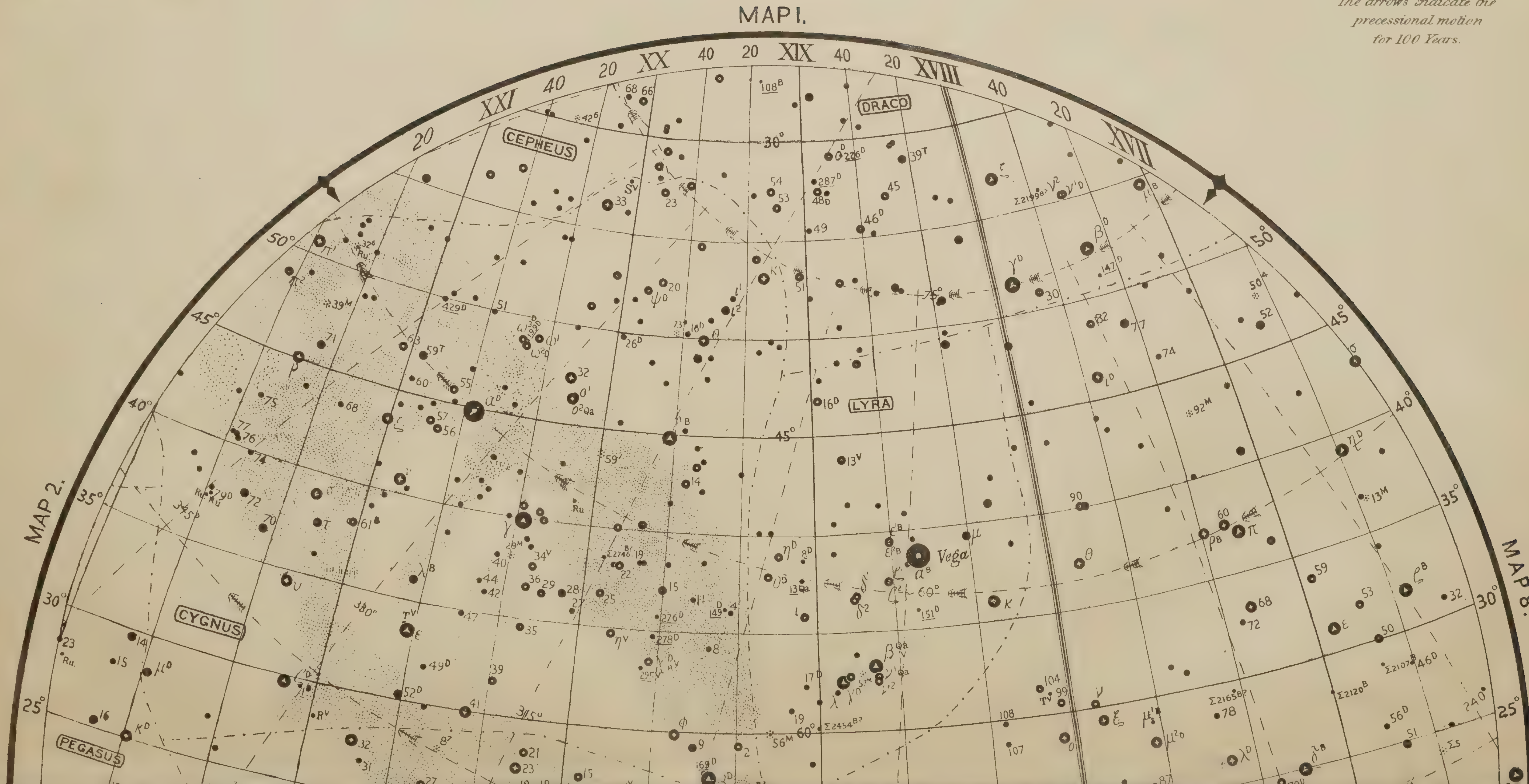
R or Ru	— *Red*	Tr	— *Trinary*
V or Va	— *Variable*	2!	— 2! *Piazzi*
D or Du	— *Double*	Σ	— *Struve*
T	— *Triple*	Δ	— *Dunlop*
Qa	— *Quadruple*	H	— *Sir W. Herschel*
Qi	— *Quintuple*	h	— *Sir J. Herschel*
B	— *Binary*		

B! — *Suspected Binary*
M (*to a Star*) — *Multiple*
M (*to a nebula*) — *Messier*
10^5 (*to a nebula*) — H. V 10.

MAP 10.

ANNO 1880.

The arrows indicate the precessional motion for 100 Years.

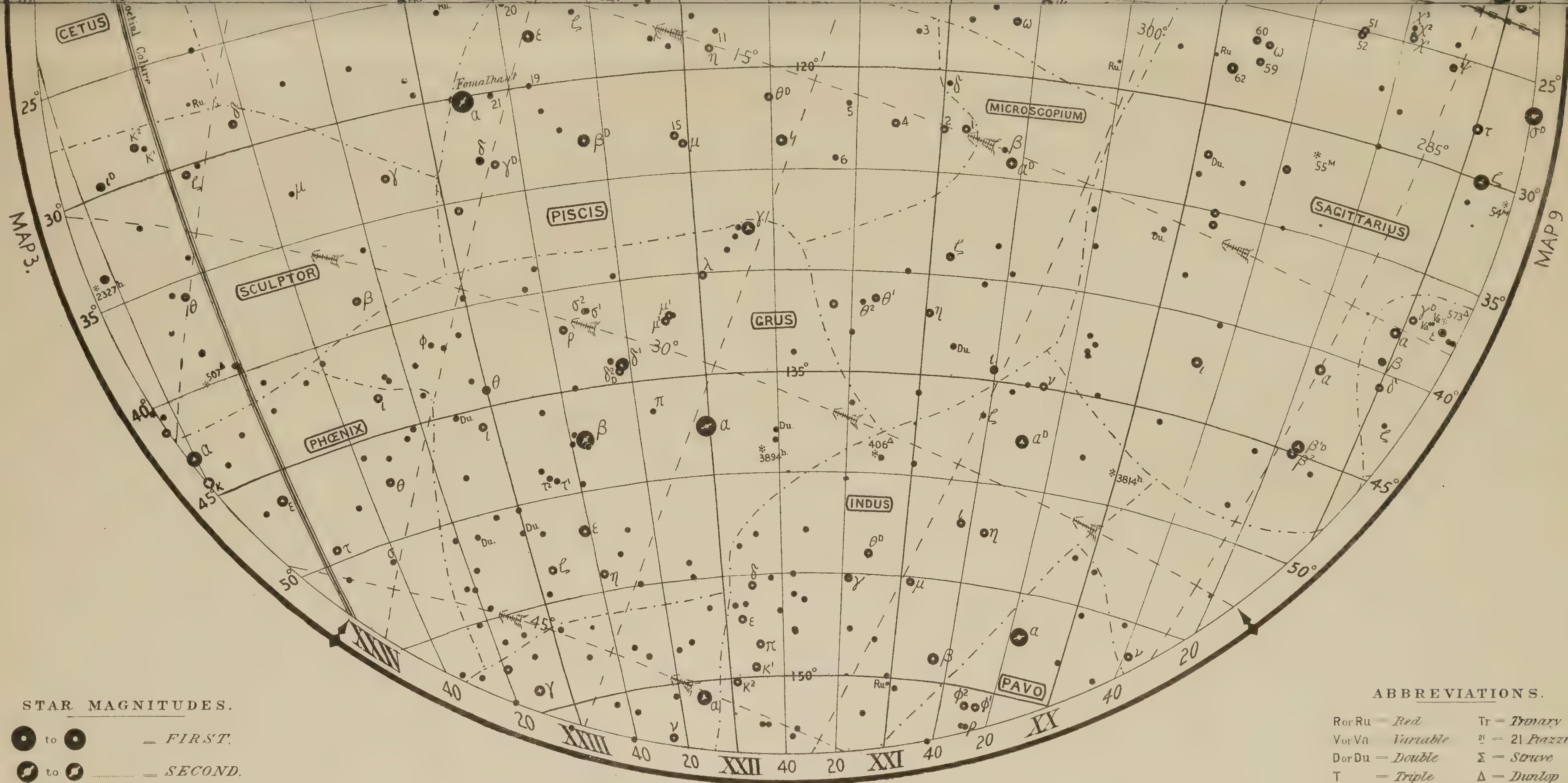


HERCULES
OPHIUCHUS
SERPENS
SAGITTA
VULPES
DELPHIN
EQUUS
AQUILA
Solstitial Colure
Equator
MAP 9.
MAP 11.
XVII
XVIII
XIX
XX
XXI
STAR MAGNITUDES.
to — FIRST.
to — SECOND.
to — THIRD.
— FOURTH.
— FIFTH.
— SIXTH.
— SEVENTH and under.
NEBULA.
ABBREVIATIONS.
R or Ru — Red
V or Va — Variable
D or Du — Double
T — Triple
Qa — Quadruple
Qi — Quintuple
B — Binary
B? — Suspected Binary
M (to a Star) — Multiple
M (to a nebula) — Messier
10⁵ (to a nebula) — H. V. 10.
Tr — Trinary
21 — 21 Piazzi
Σ — Struve
Δ — Dunlop
H — Sir W. Herschel
h — Sir J. Herschel
R. A. PROCTOR. Delt.
A. BROTHERS. Photo Litho.

MAP III.

ANNO 1880.

The arrows indicate the precessional motion for 100 Years.



MAP 12.

R.A. PROCTOR. *Delt.*

A. BROTHERS. *Photo Litho.*

STAR MAGNITUDES.

to	= *FIRST.*
to	= *SECOND.*
to	= *THIRD.*
	= *FOURTH.*
	= *FIFTH.*
	= *SIXTH.*
	= *SEVENTH.* (and under)

NEBULA.

ABBREVIATIONS.

R or Ru — *Red*	Tr = *Trinary*
V or Va — *Variable*	21 = 21 *Piazzi*
D or Du = *Double*	Σ = *Struve*
T = *Triple*	Δ = *Dunlop*
Qa = *Quadruple*	H = *Sir W. Herschel*
Qi = *Quintuple*	h = *Sir J. Herschel*
B = *Binary*	

B? = *Suspected Binary*

M (*to a Star*) = *Multiple*

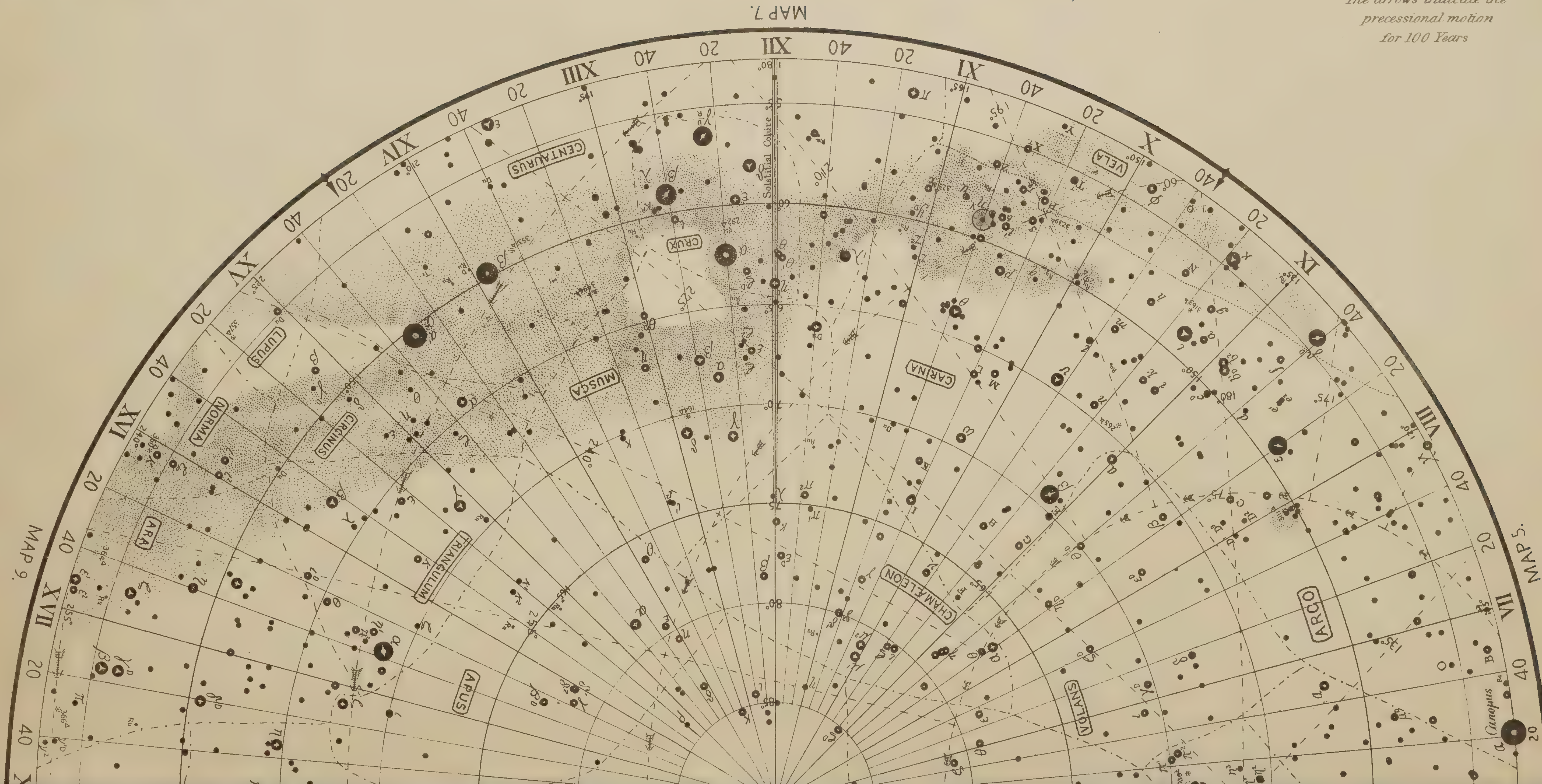
M (*to a nebula*) = *Messier*

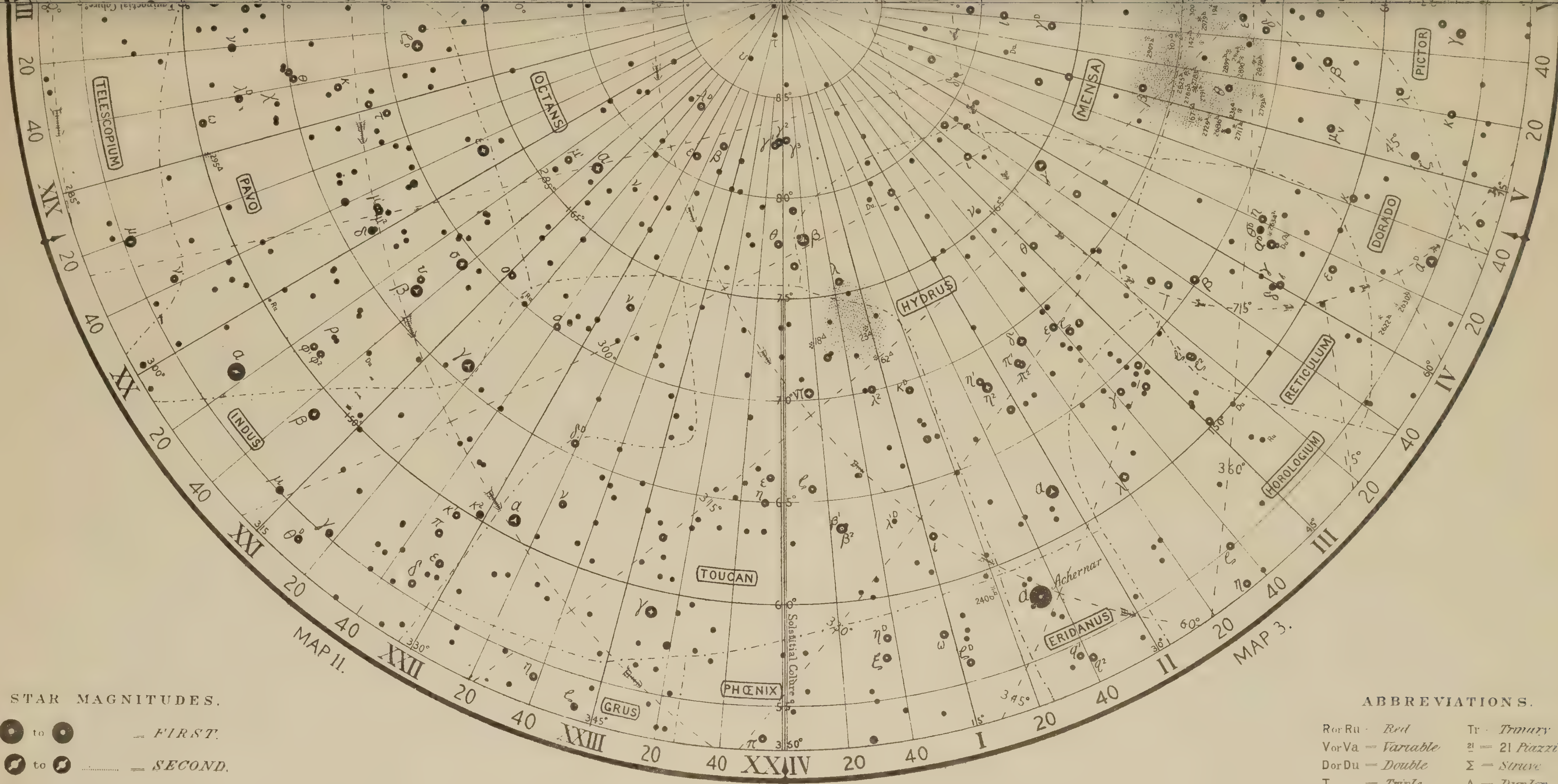
10^5 (*to a nebula*) = H. V. 10.

MAP 12.

ANNO 1880.

The arrows indicate the precessional motion for 100 Years





STAR MAGNITUDES.

- to — FIRST.
- to — SECOND.
- to — THIRD.
- — FOURTH.
- — FIFTH.
- — SIXTH.
- — SEVENTH. and under.
- NEBULA.

R.A. PROCTOR. Delt.

A. BROTHERS. Photo Litho.

ABBREVIATIONS.

R or Ru	Red	Tr	Trinary
V or Va	= Variable	21	= 21 Piazzi
D or Du	= Double	Σ	= Struve
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Qa	= Quadruple	H	= Sir W. Herschel.
Qi	= Quintuple	h	= Sir J. Herschel.
B	= Binary		

B? = Suspected Binary

M (to a Star) = Multiple.

M (to a nebula) = Messier

10⁵ (to a nebula) = H. V. 10.

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